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EQUATION OF MOTION FOR THE X-14 AIRCRAFT

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EQUATIONS OF MOTION FOR THE X-14 AIRCRAFT

Introduction

The research described in this report presents partial results of a study of the control and power requirements of the X-14 VTOL aircraft under NASA Grant NGR-05-004-051.

The complete equations of motion for the X-14 are derived in this report. The fundamental assumption is that the aircraft is a single rigid body. The equations of motion are derived with respect to a set of axes fixed to the aircraft. Additional assumptions used are that any wind disturbances are irrotational that the twin engines used on the aircraft rotate in the same direction at the same speed and that the engine exhaust is diverted by means of vanes to provide a direction varying thrust vector.

The equations obtained are subsequently linearized about various reference conditions and numerical values for the trim parameters and the stability derivatives at these conditions are tabulated at the end of the report.

CHAPTER I

DEVELOPMENT OF THE EQUATIONS OF MOTION FOR THE X-14 AIRCRAFT

A. General Equations of Motion for VTOL Aircraft

This development of the equations of motion for a VTOL aircraft assumes the aircraft is rigid and the origin of the coordinate system is at the mass center [1, 2, 3]. Additional assumptions used in this development of the equations of motion are:

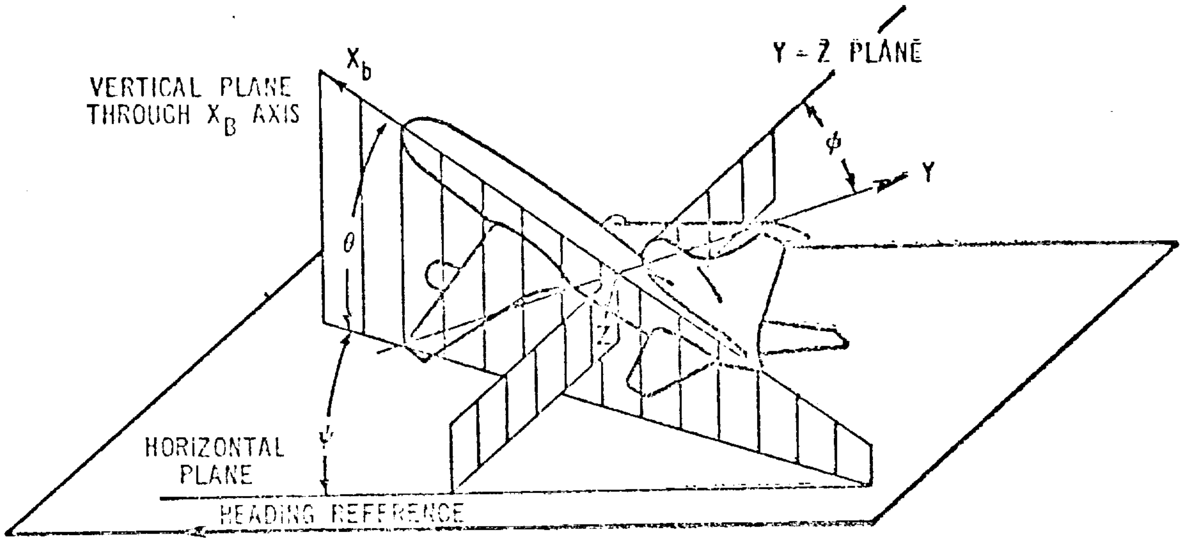
1. The VTOL aircraft has diverters and vanes affecting the engine exhaust
2. Any wind disturbance is irrotational
3. Engines rotate in the same direction at the same speed.

A standard aircraft body axis system is used where the aircraft is symmetric about the x-z plane with the positive y-axis pointing out the right wing, the z-axis down, and the x-axis in the forward direction of flight (stability axes). This is a right-handed coordinate system.

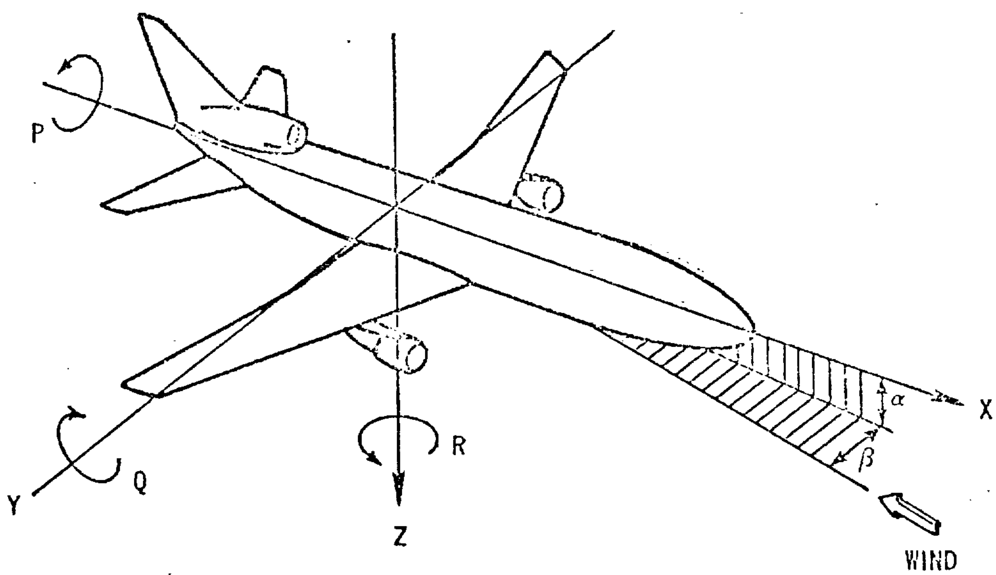
For the system, the velocities, angles, angular velocities, forces and moments associated with each axis are shown in Table A-1-1 and Figure A-1-1 [4].

Table A-1-1

Axis	Linear Velocity	Force	Angle	Angular Velocity	Moment
X	u	X or F_x	ϕ	p	L or ℓ
Y	v	Y or F_y	θ	q	M or m
Z	w	Z or F_z	ψ	r	N or n



DEFINITION OF EULER ANGLES



AIRCRAFT SIGN CONVENTION AND DEFINITION OF STABILITY AND WIND AXIS SYSTEMS

Figure A-1-1

From Etkin [1], the time derivative of the angular quantities can be expressed as

$$\dot{\theta} = q \cos\phi - r \sin\phi$$

$$\dot{\phi} = p + q \sin\phi \tan\theta + r \cos\phi \tan\theta$$

$$\dot{\psi} = (q \sin\phi + r \cos\phi) / \cos\theta$$

Since the analysis is for a VTOL aircraft, it becomes necessary to introduce some notation not normally found in airplane equations. A listing of this additional notation is in Figure A-1-2.

Inertial Forces

In writing the equations of motion, all inertial components are expressed as D'Alembert forces, i.e.,

$$\Sigma F_{external} + \Sigma F_{inertial} = 0$$

where

$$\Sigma F_{inertial} = -ma.$$

Using this notation the inertial forces along the three axes are

$$F_{xi} = -m (\dot{u} + wq - vr)$$

$$F_{yi} = -m (\dot{v} - wp + ur)$$

$$F_{zi} = -m (\dot{w} - uq + vp).$$

Likewise, the moments are

$$M_{xi} = - \dot{p} I_x + qr (I_y - I_z) + (\dot{r} + pq) I_{xz}$$

$$M_{yi} = - \dot{q} I_y + pr (I_z - I_x) + (r^2 - p^2) I_{xz}$$

$$M_{zi} = - \dot{r} I_z + pq (I_x - I_y) + (\dot{p} - qr) I_{xz}$$

Figure A-1-2

Definitions of Non-standard Notation

1. w subscript is for wind velocity
2. V_j = jet exhaust velocity from the diverters
3. σ = thrust diverter angle measured in the verticle plane from the positive z-axis
4. λ = exhaust side vane angle measured positive about the x-axis by the right hand rule
5. $U_0 = [(u - u_w)^2 + (w - w_w)^2]^{1/2}$
6. $\overline{U}_0 = [(u - u_w)^2 + (w - w_w)^2 + (v - v_w)^2]^{1/2}$
7. α = angle of attack; $\sin \alpha = (w - w_w)/U_0$
8. β = side slip angle; $\sin \beta = (v - v_w)/\overline{U}_0$
9. x_1 = distance engine intake is in front of the center of gravity
10. z_1 = distance engine intake is below the center of gravity
11. x_2 = distance engine exhaust pivot point is in front of the center of gravity
12. z_2 = distance engine exhaust pivot point is below the center of gravity
13. ℓ_1 is the effective length where the exhaust will impinge on the diverter vane from the end of the jet engine
14. I_e = moment of inertia of one engine about the axis of rotation
15. Ω_e = angular velocity of an engine measured positive in the direction of the x-axis
16. N.E. = number of engines
17. T = total thrust from the diverters
18. L_p, M_q, N_r apparent aerodynamic damping near hover not directly attributable to the effects caused by C_{ℓ_p}, C_{m_q}, C_{n_r}
19. L_{δ_x}, M_{δ_y}, N_{δ_z} Moment effects due to reaction control nozzles

20. V_{j_o} = jet velocity at the engine exhaust

21. T_o = total installed jet thrust

22. ξ_σ = longitudinal diverter efficiency factor

23. ξ_λ = lateral diverter vane efficiency factor

where

$$I_x \triangleq \int(y^2 + z^2)dm, \quad I_y \triangleq \int(x^2 + z^2)dm, \quad I_z \triangleq \int(x^2 + y^2)dm$$

$$I_{xz} \triangleq \int xzdm \quad I_{xy} \triangleq \int xydm \quad I_{yz} \triangleq \int yzdm$$

with

$$I_{xy} = 0 \text{ and } I_{yz} = 0$$

since the aircraft is symmetric about the xz plane.

In addition to aircraft inertial terms, there is a contribution from the rotation of the engines to the moment equations. If the engine speed is almost constant, the contribution to the moment equations can be expressed as

$$M_{e_x} = 0$$
$$M_{e_y} = (N.E.)\ I_e\ \Omega_e r$$
$$M_{e_z} = -(N.E.)\ I_e\ \Omega_e q$$

Gravitational Forces

Since the origin of the coordinate system is at the center of gravity, the gravitational forces do not enter into the moment equations. Their contribution to the force equations is

$$F_{x_g} = -W \sin \theta$$
$$F_{y_g} = W \sin \phi \cos \theta$$
$$F_{z_g} = W \cos \phi \cos \theta$$

Mass Flow Effects

There are two contributions to mass flow effects, one at the engine intakes and a second effect at the engine exhausts. If the mass of the fuel burned is neglected, the forces due to the mass flow can be expressed as

$$F_{x_{\dot{m}}} = -\dot{m}\ (u - u_w - V_j \sin \sigma \cos \lambda)$$
$$F_{y_{\dot{m}}} = -\dot{m}\ (v - v_w - V_j \sin \lambda)$$
$$F_{z_{\dot{m}}} = -\dot{m}\ (w - w_w + V_j \cos \sigma \cos \lambda)$$

where $\dot{m}$ is the entering mass flow rate which is approximately equal to the mass flow rate out, V_j is the relative exhaust velocity of the jet, σ is the diverter angle, and λ is the side vane angle. Recalling that the gross thrust equals mass flow rate times relative velocity,

$$T = \dot{m}\, V_j$$

or

$$\dot{m} = \frac{T}{V_j}$$

Upon making this substitution, the mass flow contributions to the equations of motion can be written as

$$F_{x_{\dot{m}}} = T\,[\sin\,\sigma\cos\,\lambda - (u - u_w)/V_j]$$
$$F_{y_{\dot{m}}} = T\,[\sin\,\lambda - (v - v_w)/\,V_j]$$
$$F_{z_{\dot{m}}} = -T\,[\cos\,\sigma\cos\,\lambda + (w - w_w)/V_j]$$

The mass flow contributions to the moment equations enter in because the intakes and exhausts are not at the center of gravity. The moments are

$$M_{x_{\dot{m}_{in}}} = T\,z_1\,(v - v_w)/V_j$$
$$M_{y_{\dot{m}_{in}}} = T\,[x_1\,(w - w_w) - z_1\,(u - u_w)]/V_j$$
$$M_{z_{\dot{m}_{in}}} = -T\,x_1\,(v - v_w)/V_j$$

where x_1 and z_1 are the distances from the center of gravity to the center of the intakes. The moments caused by the exhaust are

$$M_{x_{\dot{m}_{out}}} = -T\,\sin\,\lambda(z_2 + \ell_1\,\cos\,\sigma)$$
$$M_{y_{\dot{m}_{out}}} = T\,\cos\,\lambda\,(z_2\,\sin\,\sigma + x_2\,\cos\,\sigma)$$
$$M_{z_{\dot{m}_{out}}} = T\,\sin\,\lambda\,(x_2 - \ell_1\,\sin\,\sigma)$$

where x_2 and z_2 are the distances from the center of gravity to the center of the exhausts, and ℓ_1 is the effective length where the exhaust will impinge on the diverter vane.

The total moments caused by engine mass flow terms can now be expressed as

$$M_{x_{\dot{m}}} = T\,[-\sin\lambda\,(z_2 + \ell_1 \cos\sigma) + z_1\,(v - v_w)/V_j]$$
$$M_{y_{\dot{m}}} = T\,\{\cos\lambda\,(z_2 \sin\sigma + x_2 \cos\sigma) + [x_1\,(w - w_w) - z_1\,(u - u_w)]/V_j\}$$
$$M_{z_{\dot{m}}} = T\,[\sin\lambda(x_2 - \ell_1 \sin\sigma) - x_1\,(v - v_w)/V_j]$$

Additional moments are caused by discharge nozzles in the tail and on the wing tips. These reaction control moments can be written as

$$M_{x_{R.C.}} = L_{\delta_x}\ \delta_x$$
$$M_{y_{R.C.}} = M_{\delta_y}\ \delta_y$$
$$M_{z_{R.C.}} = N_{\delta_z}\ \delta_z$$

where δ_x, δ_y and δ_z are the reaction nozzle openings expressed in degrees.

Aerodynamic Expressions

The complete aerodynamic expressions for a conventional airplane can be written as

$$X_{aero} = \frac{\rho}{2} U_o^{\,2}\ S\ C_x$$

$$Y_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2}\ S\ C_y$$

$$Z_{aero} = \frac{\rho}{2} U_o^{\,2}\ S\ C_z$$

$$L_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2}\ S\ b\ C_\ell$$

$$M_{aero} = \frac{\rho}{2} U_o^{\,2}\ S\ c\ C_m$$

$$N_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2}\ S\ b\ C_n$$

where C_x, C_y, C_z, C_ℓ, C_m and C_n are the non-dimensional aerodynamic coefficients, ρ is the air density, $U_o = [(u - u_w)^2 + (w - w_w)^2]^{1/2}$, $\overline{U}_o = [(u - u_w)^2 + (w - w_w)^2 + (v - v_w)^2]^{1/2}$, S is the wing area, b is the span and c is the wing chord.

Now use a Taylor series expansion of the non-dimensional aerodynamic forces retaining only the first terms in the series [1, 2] and let the vehicle velocities relative to the air mass be denoted by $u_{rel} \stackrel{\Delta}{=} u - u_w$, $v_{rel} \stackrel{\Delta}{=} v - v_w$ and $w_{rel} \stackrel{\Delta}{=} w - w_w$. Then,

$$C_x = C_{x_0} + \frac{\partial C_x}{\partial \alpha}\alpha + \frac{\partial C_x}{\partial U}u_{rel} + \frac{\partial C_x}{\partial \delta_e}\delta_e$$

$$C_y = C_{y_0} + \frac{\partial C_y}{\partial \beta}\beta + \frac{\partial C_y}{\partial p}p + \frac{\partial C_y}{\partial r}r + \frac{\partial C_y}{\partial \delta_r}\delta_r$$

$$C_z = C_{z_0} + \frac{\partial C_z}{\partial \alpha}\alpha + \frac{\partial C_z}{\partial u}u_{rel} + \frac{\partial C_z}{\partial q}q + \frac{\partial C_z}{\partial \dot{\alpha}}\dot{\alpha} + \frac{\partial C_z}{\partial \delta_e}\delta_e$$

$$C_\ell = C_{\ell_0} + \frac{\partial C_\ell}{\partial \beta}\beta + \frac{\partial C_\ell}{\partial p}p + \frac{\partial C_\ell}{\partial r}r + \frac{\partial C_\ell}{\partial \delta_a}\delta_a + \frac{\partial C_\ell}{\partial \delta_r}\delta_r$$

$$C_m = C_{m_0} + \frac{\partial C_m}{\partial \alpha}\alpha + \frac{\partial C_m}{\partial u}u_{rel} + \frac{\partial C_m}{\partial q}q + \frac{\partial C_m}{\partial \dot{\alpha}}\dot{\alpha} + \frac{\partial C_m}{\partial \delta_e}\delta_e$$

$$C_n = C_{n_0} + \frac{\partial C_n}{\partial \beta}\beta + \frac{\partial C_n}{\partial p}p + \frac{\partial C_n}{\partial r}r + \frac{\partial C_n}{\partial \delta_a}\delta_a + \frac{\partial C_n}{\partial \delta_r}\delta_r$$

where α is the angle of attack ($\sin\alpha = w_{rel}/\,U_0$), β is the side slip angle ($\cos\beta = U_0\;/\;\overline{U}_0$), and δ_e, δ_a and δ_r are the elevator, aileron and rudder deflections, respectively.

Following Etkin [2], if the partial derivatives are written as non-dimensional stability derivatives, the aerodynamic portions of the equations of motion become

$$X_{aero} = \frac{\rho}{2}U_o^2\,S[C_{x_o} + C_{x_\alpha}\alpha + \frac{1}{U_o}C_{x_u}u_{rel} + C_{x_{\delta_e}}\delta_e]$$

$$Y_{aero} = \frac{\rho}{2}\overline{U}_o^2\,S[C_{y_o} + C_{y_\beta}\beta + \frac{b}{2\overline{U}_o}C_{y_p}p + \frac{b}{2\overline{U}_o}C_{y_r}r + C_{y_{\delta_r}}\delta_r]$$

$$Z_{aero} = \frac{\rho}{2}\overline{U}_o^2\,S[C_{z_o} + C_{z_\alpha}\alpha + \frac{1}{U_o}C_{z_u}u_{rel} + \frac{c}{2\overline{U}_o}C_{z_q}q + \frac{c}{2\overline{U}_o}C_{z_{\dot{\alpha}}}\dot{\alpha} + C_{z_{\delta_e}}\delta_e]$$

$$L_{aero} = \frac{\rho}{2} \bar{U}_o^{\,2} \, Sb[C_{\ell_o} + C_{\ell_\beta} \beta + \frac{b}{2\bar{U}_o} C_{\ell_p} p + \frac{b}{2\bar{U}_o} C_{\ell_r} r + C_{\ell_{\delta_a}} \delta_a + C_{\ell_{\delta_r}} \delta_r]$$

$$M_{aero} = \frac{\rho}{2} U_o^{\,2} \, Sc[C_{m_o} + C_{m_\alpha} \alpha + \frac{1}{U_o} C_{m_u} u_{rel} + \frac{c}{2U_o} C_{m_q} q + \frac{c}{2U_o} C_{m_{\dot{\alpha}}} \dot{\alpha} + C_{m_{\delta_e}} \delta_e]$$

$$N_{aero} = \frac{\rho}{2} \bar{U}_o^{2} \, Sb[C_{n_o} + C_{n_\beta} \beta + \frac{b}{2\bar{U}_o} C_{n_p} p + \frac{b}{2\bar{U}_o} C_{n_r} r + C_{n_{\delta_a}} \delta_a + C_{n_{\delta_r}} \delta_r]$$

In addition to these stability derivatives normally found in airplane equations, for VTOL aircraft it is desirable to add the rotational damping observed on a hovering airplane. This can be expressed as:

$$L_{aero\ VTOL} = L_p \, p$$

$$M_{aero\ VTOL} = M_q \, q$$

$$N_{aero\ VTOL} = N_r \, r$$

After summing the component parts, the complete non-linear equations of motion for a VTOL aircraft can be written as in Fig. A-1-3.

Figure A-1-3

Summary of Complete Non-linear Equations of Motion for a VTOL Aircraft

$$\dot{u} = vr - wq - g \sin\theta + \frac{T}{m}\left[\sin\sigma \cos\lambda - \frac{1}{V_j}(u - u_w)\right] + \frac{1}{2m}\rho U_0^2 S \left[C_{x_0} + C_{x_\alpha}\alpha + \frac{1}{U_0}C_{x_u}(u - u_w) + C_{x_{\delta_e}}\delta_e\right] \qquad \text{(A-1-1)}$$

$$\dot{v} = wp - ur + g \sin\phi \cos\theta + \frac{T}{m}\left[\sin\lambda - \frac{1}{V_j}(v - v_w)\right] + \frac{\rho \bar{U}_0^2 S}{2m} \left[C_{Y_0} + C_{Y_\beta}\beta + \frac{b}{2\bar{U}_0}C_{Y_p} p + \frac{b}{2\bar{U}_0}C_{Y_r} r + C_{Y_{\delta_r}}\delta_r\right] \qquad \text{(A-1-2)}$$

$$\dot{w} = uq - vp + g\cos\phi\cos\theta - \frac{T}{m}\left[\cos\sigma\cos\lambda + \frac{1}{V_j}(w - w_w)\right] + \frac{\rho U_0^2 S}{2m}\left[C_{z_0} + C_{z_\alpha}\alpha + \frac{1}{U_0}C_{z_u}(u - u_w) + \frac{c}{2U_0}C_{z_q} q + \frac{c}{2U_0}C_{z_{\dot{\alpha}}}\dot{\alpha} + C_{z_{\delta_e}}\delta_e\right] \qquad \text{(A-1-3)}$$

$$\dot{p} = \frac{(I_y - I_z)}{I_x} qr + \frac{I_{xz}}{I_x}(\dot{r} + pq) + \frac{T}{I_x}\left[-\sin\lambda\,(z_2 + \ell_1\cos\sigma) + \frac{z_1}{V_j}(v - v_w)\right] + \frac{L_p}{I_x}p + \frac{L_{\delta_x}}{I_x}\delta_x + \rho\frac{\bar{U}_0^2 Sb}{2I_x}\left[C_{\ell_0} + C_{\ell_\beta}\beta + \frac{b}{2\bar{U}_0}C_{\ell_p} p + \frac{b}{2\bar{U}_0}C_{\ell_r} r + C_{\ell_{\delta_a}}\delta_a + C_{\ell_{\delta_r}}\delta_r\right] \qquad \text{(A-1-4)}$$

$$\dot{q} = \frac{(I_z - I_x)}{I_y} pr + \frac{I_{xz}}{I_y}(r^2 - p^2) - \frac{1}{I_y}(\text{N.E.})\, I_e \Omega_e r + \frac{T}{I_y} \left\{\cos\lambda(z_2 \sin\sigma + x_2\cos\sigma) + \frac{1}{V_j}\left[x_1(w - w_w) - z_1(u - u_w)\right]\right\}$$

$$+ \frac{M_q}{I_y} q + \frac{M_{\delta_y}}{I_y} \delta y + \frac{\rho U_0{}^2 Sc}{2I_y} [C_{m_0} + C_{m_\alpha} \alpha + \frac{1}{U_0} C_{m_u} (u - u_w) \tag{A-1-5}$$

$$+ \frac{C}{2U_0} C_{m_q} q + \frac{C}{2U_0} C_{m_{\dot\alpha}} \dot\alpha + C_{m_{\delta_e}} \delta_e]$$

$$\dot r = \frac{(I_x - I_y)}{I_z} pq + \frac{I_{xz}}{I_z} (\dot p - qr) + \frac{1}{I_z} (N.E.)\ I_e \Omega_e q$$

$$+ \frac{T}{I_z} [\sin \lambda (x_2 - \ell_1 \sin \sigma) - \frac{x_1}{V_j} (v - v_w)] + \frac{N_r}{I_z} r \tag{A-1-6}$$

$$+ \frac{N_{\delta_z}}{I_z} \delta_z + \frac{\rho \bar U_0{}^2 Sb}{2I_z} [C_{n_0} + C_{n_\beta} \beta + \frac{b}{2\bar U_0} C_{n_p} p + \frac{b}{2\bar U_0} C_{n_r} r$$

$$+ C_{n_{\delta_a}} \delta_a + C_{n_{\delta_r}} \delta_r]$$

B. Application of the Equations of Motion to the X-14 Aircraft

Several of the above aerodynamic stability derivatives have a very small effect in the representation of the dynamics of the X-14. The determination of which stability derivatives have this insignificant effect was based upon examination of wind tunnel data and a knowledge of the physical airplane. The final justification for retaining or neglecting different stability derivatives comes from the fact that an analytical model was obtained which when used in simulator studies closely approximated the physical airplane [5]. Using these findings the above aerodynamic contribution to the equations of motion can be expressed as

$$X_{aero} = \frac{\rho}{2} U_o^{\,2} \; S\,(C_L \sin\alpha - C_D \cos\alpha)$$

$$Y_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2} \; S\,C_Y$$

$$Z_{aero} = \frac{-\rho U_o^{\,2}}{2} \; S\,(C_L \cos\alpha + C_D \sin\alpha)$$

$$L_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2} \; Sb\,(C_{\ell_o} + C_{\ell_{\delta_a}} \delta_a) + L_p\, p$$

$$M_{aero} = \frac{\rho}{2} U_o^{\,2} \; Sc\,(C_{m_o} + C_{m_\alpha} \alpha + \frac{c}{2U_o} C_{m_q} q + C_{m_{\delta_e}} \delta_e) + M_q\, q$$

$$N_{aero} = \frac{\rho}{2} \overline{U}_o^{\,2} \; Sb\,(C_{n_o} + C_{n_{\delta_r}} \delta_r + C_{n_{\delta_a}} \delta_a) + N_r\, r$$

where C_L is the non-dimensional lift coefficient and C_D is the drag coefficient[2].

Continuing to follow the development in reference [5], some of the above "power on" stability derivatives are expressed as "power off" plus " Δ" terms where the " Δ" represents the difference between power on and power off effects. The aerodynamic portion of the equations of motion now becomes

$$X_{aero} = \frac{\rho}{2} U_o^{\,2} \; S[(C_{L_{power\ off}} + \Delta\, C_L)\sin\alpha - C_D \cos\alpha]$$

$$Y_{aero} = \frac{\rho}{2} \bar{U}_o^2 \, S \, C_Y$$

$$Z_{aero} = -\frac{\rho}{2} U_o^2 \, S \, [(C_{L_{\text{power off}}} + \Delta C_L) \cos\alpha + C_D \sin\alpha]$$

$$L_{aero} = \frac{\rho}{2} \bar{U}_o^2 \, Sb \, (C_{\ell_o} + C_{\ell_{\delta_a}} \delta_a) + L_p \, p$$

$$M_{aero} = \frac{\rho}{2} U_o^2 \, Sc \, [(C_{m_{o_{\text{power off}}}} + \Delta C_M) + (C_{m_{\alpha_{\text{power off}}}} + \Delta C_{M_\alpha}) \alpha$$

$$+ \frac{C}{2U_o} C_{m_q} q + C_{m_{\delta_e}} \delta_e] + M_q \, q$$

$$N_{aero} = \frac{\rho}{2} \bar{U}_o^2 \, Sb \, (C_{n_o} + C_{n_{\delta_r}} \delta_r + C_{n_{\delta_a}} \delta_a) + N_r \, r$$

Upon incorporating these expressions for the aerodynamic forces in the complete equations of motion, the reduced non-linear equations of motion for the X-14 can be written as in Fig. A-1-4.

These equations can be put in state variable form by eliminating the derivative terms from the right hand side of equations (A-1-10) and A-1-12). Rewrite the equations as

$$I_x \dot{p} = I_{xz} \dot{r} + L^*$$
$$I_z \dot{r} = I_{xz} \dot{p} + N^* \qquad \text{(A-1-13)}$$

where

$$L^* = (I_y - I_z)\ qr + I_{xz}\ pq + T[-\sin\lambda\ (z_2 + \ell_1\ \cos\sigma)$$

$$+ z_1\ (v - v_w)\ /\ V_j] + L_p\ p + L_{\delta_x}\ \delta_x +$$

$$+ 1/2\rho\ \ \bar{U}_0^{\ 2}\ Sb\ (C_{\ell_0} + C_{\ell_{\delta_a}}\ \delta_a)$$

$$N^* = (I_x - I_y)\ pq - I_{xz}\ q\ r + 2\ I_e\Omega_e q$$

$$+ T\ [\sin\lambda\ (x_2 - \ell_1\ \sin\sigma) - x_1\ (v - v_w\ )/V_j] + N_r\ r$$

$$+ N_{\delta_z}\ \delta_z + 1/2\ \rho\ \bar{U}_o^{\ 2}\ Sb\ (C_{n_o} + C_{n_{\delta_r}}\ \delta_r\ + C_{n_{\delta_a}}\ \delta_a)$$

Upon solving Eqns. (A-1-13) for $\dot{p}$ and $\dot{r}$ it is found that

$$\dot{p} = (I_z\ L^* + I_{xz}\ N^*)/(I_x\ I_z - I_{xz}^{\ 2})$$

$$\dot{r} = (I_{xz}\ L^* + I_x\ N^*)/(I_x\ I_z - I_{xz}^{\ 2})$$

Figure A-1-4

Summary of the Reduced Non-Linear Equations of Motion for the X-14 Aircraft

$$\dot{u} = vr - wq - g \sin\theta + \frac{T}{m}\left[\sin\sigma \cos\lambda - \frac{1}{V_j}(u - u_w)\right] + \frac{1}{2m}\rho U_0^2 S\left[(C_{L_{p.\,off}} + \Delta C_L)\sin\alpha - C_D \cos\alpha\right] \quad \text{(A-1-7)}$$

$$\dot{v} = wp - ur + g \sin\phi \cos\theta + \frac{T}{m}\left[\sin\lambda - \frac{1}{V_j}(v - v_w)\right] + \frac{1}{2m}\rho \bar{U}_0^2 S C_Y \quad \text{(A-1-8)}$$

$$\dot{w} = uq - vp + g \cos\phi \cos\theta - \frac{T}{m}\left[\cos\sigma \cos\lambda + \frac{1}{V_j}(w - w_w)\right] - \frac{1}{2m}\rho U_0^2 S\left[(C_{L_{p.\,off}} + \Delta CL)\cos\alpha + C_D \sin\alpha\right] \quad \text{(A-1-9)}$$

$$\dot{p} = \frac{(I_y - I_z)}{I_x} qr + \frac{I_{xz}}{I_x}(\dot{r} + pq) + \frac{T}{I_x}\left[-\sin\lambda\,(z_2 + \ell_1 \cos\sigma) + \frac{z_1}{V_j}(v - v_w)\right] + \frac{L_p}{I_x} p + \frac{L_{\delta_x}}{I_x}\delta_x + \frac{1}{2I_x}\rho \bar{U}_0^2 Sb\,(C_{\ell_0} + C_{\ell_{\delta_a}}\delta_a) \quad \text{(A-1-10)}$$

$$\dot{q} = \frac{(I_z - I_x)}{I_y} pr + \frac{I_{xz}}{I_y}(r^2 - p^2) - \frac{1}{I_y} 2 I_e \Omega_e r + \frac{T}{I_y}\cos\lambda\,(z_2 \sin\sigma + x_2 \cos\sigma) + \frac{1}{V_j}\left[x_1 (w - w_w) - z_1 (u - u_w)\right] + \frac{M_q}{I_y} q + \frac{M_{\delta_y}}{I_y}\delta_y + \frac{1}{2I_y}\rho U_0^2 Sc\left[(C_{M_{0_{p.\,off}}} + \Delta C_{m_0}) + (C_{m_{\alpha_{p.\,off}}} + \Delta C_{m_\alpha})\alpha + \frac{c}{2U_0} C_{m_q} q + C_{m_{\delta_e}}\delta_e\right] \quad \text{(A-1-11)}$$

$$\dot{r} = \frac{(I_x - I_y)}{I_z} pq + \frac{I_{xz}}{I_z}(\dot{p} - qr) + \frac{1}{I_z} 2 I_e \Omega_e q + \frac{T}{I_z}\left[\sin\lambda\,(x_2 - \ell_1 \sin\sigma) - \frac{x_1}{V_j}(v - v_w)\right] + \frac{N_r}{I_z} r + \frac{N_{\delta_z}}{I_z}\delta_z + \frac{1}{2I_z}\rho \bar{U}_0^2 Sb\,(C_{n_0} + C_{n_{\delta_r}}\delta_r + C_{n_{\delta_a}}\delta_a) \quad \text{(A-1-12)}$$

C. Numerical Evaluation of the X-14 Equations of Motion

Numerical values for the constants in equations (A-1-7) to (A-1-12) are given in Table A-1-2. In addition, the following stability derivatives can be expressed as functional relationships [5]:

$$C_{\ell_{\delta_a}} = 0.0030 \cos^2\beta/\ \text{deg}$$

$$C_{n_{\delta_a}} = -0.00014 \cos^2\beta/\ \text{deg}$$

$$C_{n_{\delta_r}} = 0.00118 \quad \cos^2\beta/\ \text{deg}$$

$$C_{m_{\delta_e}} = -0.0178/\ \text{deg}$$

Furthermore, Figures (A-1-5) through A-1-12) show graphs of C_{ℓ_0}, C_Y, C_{n_0}, $C_{m_{\alpha_{\text{power off}}}}$, $C_{L_{\text{power off}}}$, $C_{M_{0_{\text{power off}}}}$, C_D, $\Delta C_{m_0}/T_c$, $\Delta C_L/T_c$ and T_o vs. RPM. T_c is the non-dimensionalized thrust with $T_c = T/(1/2 \quad U_0^2\ S)$. T_o is the thrust at the engine exhaust and T is the thrust at the end of the diverters. Hence,

$$T = T_o\ \xi_\sigma\ \xi_\lambda$$

where ξ_σ is the longitudinal diverter efficiency factor and ξ_λ is the lateral side vane efficiency factor. Also,

$$V_j = V_{j_o}\ \xi_\sigma\ \xi_\lambda$$

which demonstrate that the jet velocity is somewhat less at the exit of the diverters than at the exit of the engines. In order to reduce these graphs to a useable form, functional relationships must be obtained. It was attempted to fit all of the graphs with polynomial curves. This, however, was impractical for the more irregular functions and straight line approximations were used. The functions used are shown in Table A-1-3.

The reaction control nozzle effects were evaluated by two independent methods. The X-14's response to sinusoidal inputs was analyzed by NASA at Moffet Field. The second method is to note that

$$\text{moment} = M_{\delta_y} \delta_y = \text{Force} \cdot \text{Length}$$

or

$$M_{\delta_y} \delta_{y_{max}} = F_{max} \cdot \text{length}$$

where the length is the distance to the discharge nozzle. F_{max} was measured directly using transducers, and $\delta_{y_{max}}$ was also measured directly. Numerical values associated with these calculations and a comparison with the other method are shown in Table A-1-4. This agreement is quite good, especially when considering the errors and uncertainties involved in measuring quantities like the moments of inertia and the maximum force at the nozzle outlets.

Table A-1-2

X-14 Constant Parameters

ρ	$= 2.378 \times 10^{-3}$ slugs/ft^3
weight	= 4182 lb.
I_x	= 2340 slug-ft^2
I_y	= 3400 slug-ft^2
I_z	= 5400 slug-ft^2
I_{x_z}	= 180 slug-ft^2

mass center at station 99.84 in. and 0.58 in. right of center line

x_1	= 6 ft.
x_2	= -0.0133 ft.
z_1	= 0.583 ft.
z_2	= 0.916 ft.
ℓ_1	= 0.167 ft.
Ω_e	= 1728 rad/sec at 100% RPM
I_e	= 0.5 slug ft^2
S	= 182.69 ft^2
c	= 5.56 ft.
m	= 129.9 slugs
b	= 33.83 ft.
M_q/I_y	= -0.15 sec^{-1}
L_p/I_x	= -0.45 sec^{-1}
N_r/I_z	= -0.20 sec^{-1}
C_{m_q}	= -11.4

$C_{m_{\delta_e}} = -0.0178 \text{ deg}^{-1}$

$\Delta C_{m_\alpha} = 0.576 \text{ rad}^{-1}$

$M_{\delta_y}/I_y = 0.0350 \text{ rad/sec}^2/\text{deg}$

$N_{\delta_z}/I_z = 0.0166 \text{ rad/sec}^2/\text{deg}$

$L_{\delta_x}/I_x = 0.0631 \text{ rad/sec}^2/\text{deg}$

$V_{j_o} = 2000 \text{ ft/sec}$

$\xi_\sigma = 0.91$

$\xi_\lambda = 1.00$

Table A-1-3

$T = T_o(\Omega)$ with Ω in percent of maximum RPM and T in pounds (for one engine only)

$T_o = 44.15011 * \Omega - 1869.205$	$\Omega < 93.3$
$= 68.96552 * \Omega - 4184.483$	$93.3 < \Omega < 99.1$
$= 80 * \Omega - 5278.$	$99.1 < \Omega < 100.1$
$= 18.18182 * \Omega + 910.$	$100.1 < \Omega < 101.2$

$\Omega = \Omega(T_o)$

$\Omega = 0.02265 * T_o + 42.3375$	$T_o < 2250$
$= .0145 * T_o + 60.675$	$2250 < T_o < 2650$
$= .0125 * T_o + 65.975$	$2650 < T_o < 2730$
$= .055 * T_o - 50.05$	$2730 < T_o < 2750$

$\Delta C_L/T_c = f\ (U_O)$

$$\Delta C_L/T_c = -2.248398 \times 10^{-7}\ U_O^{\ 3} + 2.483009 \times 10^{-5}\ U_O^{\ 2} - 1.332149 \times 10^{-3}\ U_O$$

$\Delta C_M/T_c = f\ (U_O)$

$$\Delta C_M/T_c = 4.900354 \times 10^{-7}\ U_O 3 - 3.164620 \times 10^{-5}\ U_O^{\ 2} + 1.529505 \times 10^{-3}\ U_O$$

$C_D = C_D(U_O)$

$$C_D = .11 + 1./(2.152195\ U_O + 12.5)$$

$C_{M_{O\,power\ off}} = C_{M_{O\,power\ off}}(U_O)$

$C_{M_{O\,power\ off}} = -0.6 + 0.00237\ U_O$	$U_O < 34$ (ft/sec)
$= -0.52 + 0.0148\ (U_O - 34)$	$34 < U_O < 51$
$= -0.27 + 0.001579\ (U_O - 51)$	$51 < U_O < 101$
$= -0.19$	$U_O > 101$

$$C_{M_{\alpha_{\text{power off}}}} = C_{M_{\alpha_{\text{power off}}}} (U_0)$$

$$C_{M_{\alpha_{\text{power off}}}} = -4.1 + 0.04145\ U_0 \qquad U_0 < 34\ (\text{ft/sec})$$

$$= -2.7 + 0.1007\ (U_0 - 34) \qquad 34 < U_0 < 51$$

$$= -1.0 \qquad U_0 > 101$$

$$C_Y = C_Y\ (\beta)$$

$$C_Y = -1.8513 \qquad 0 < \beta < 0.189\ (\text{rad})$$

$$= -0.35 + 0.393\ (\beta - 0.189) \qquad 0.189 < \beta < 0.418$$

$$= -0.26 - 0.362\ (\beta - 0.418) \qquad 0.418 < \beta < 1.22$$

$$= -0.55 \qquad \beta > 1.22$$

$$C_{n_0} = C_{n_0}\ (\beta)$$

$$C_{n_0} = 0.113\ \beta \qquad 0 < \beta < 0.1945\ (\text{rad})$$

$$= 0.022 \qquad 0.1945 < \beta < 0.594$$

$$= 0.022 + 0.1348\ (\beta - 0.594) \qquad 0.594 < \beta < 1.395$$

$$= 0.13 \qquad \beta > 1.395$$

$$C_{\ell_0} = C_{\ell_0}\ (\beta)$$

$$C_{\ell_0} = -0.083\ \beta \qquad 0 < \beta < 0.169\ (\text{rad})$$

$$= -0.014 + 0.0066\ (\beta - 0.169) \qquad 0.169 < \beta < 0.471$$

$$= -0.012 - 0.00865\ (\beta - 0.471) \qquad 0.471 < \beta < 1.395$$

$$= -0.02 \qquad \beta > 1.395$$

$$C_{L_{\text{power off}}} = C_{L_{\text{power off}}}\ (U_0)$$

$$C_{L_{\text{power off}}} = 0.61 + 0.002763\ U_0 \qquad U_0 < 51\ (\text{ft/sec})$$

$$= 0.75 \qquad U_0 > 51$$

Table A-1-4

Axis	Discharge Point	Length	δ_{max}	F_{max}	Inertia	Calculated Sensitivity	NASA Sensitivity
X	Wing Tip	16.9 ft.	20°	200 lbs.	2340 slug ft.^{2}	4.13 deg/sec^2/deg	3.9 deg/sec^2/deg
Y	Tail	18.75 ft.	20°	130 lbs.	3400 slug ft.^{2}	2.05 deg/sec^2/deg	2.0 deg/sec^2/deg
Z	Tail	18.75 ft.	20°	90 lbs.	5400 slug ft.^{2}	.90 deg/sec^2/deg	.95 deg/sec^2/deg

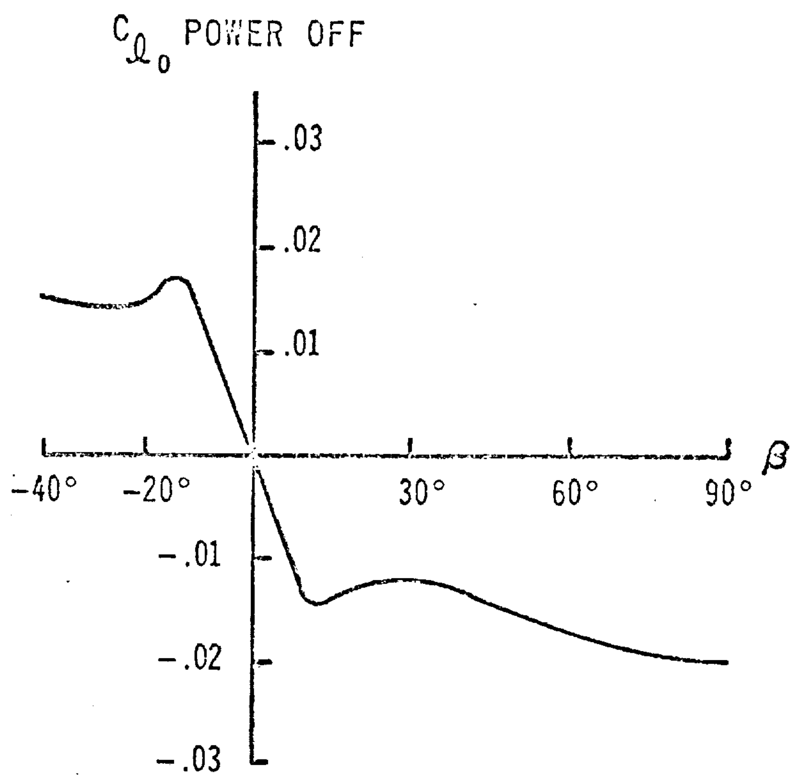


Figure A-1-5. C_{ℓ_0} Power Off vs. β

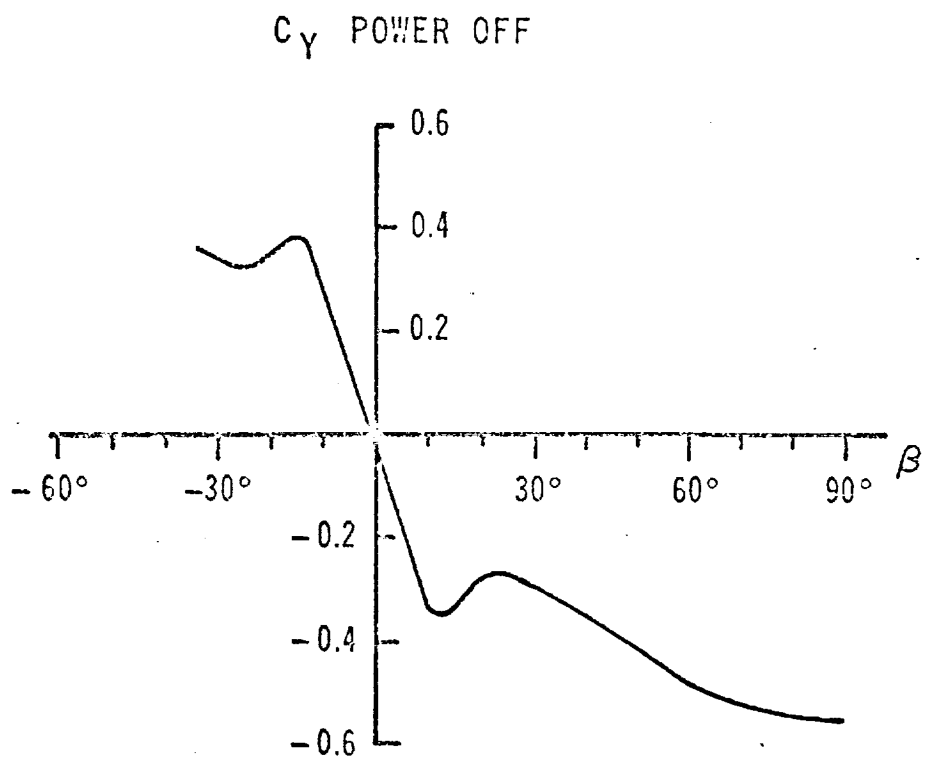


Figure A-1-6 C_Y Power Off vs. β

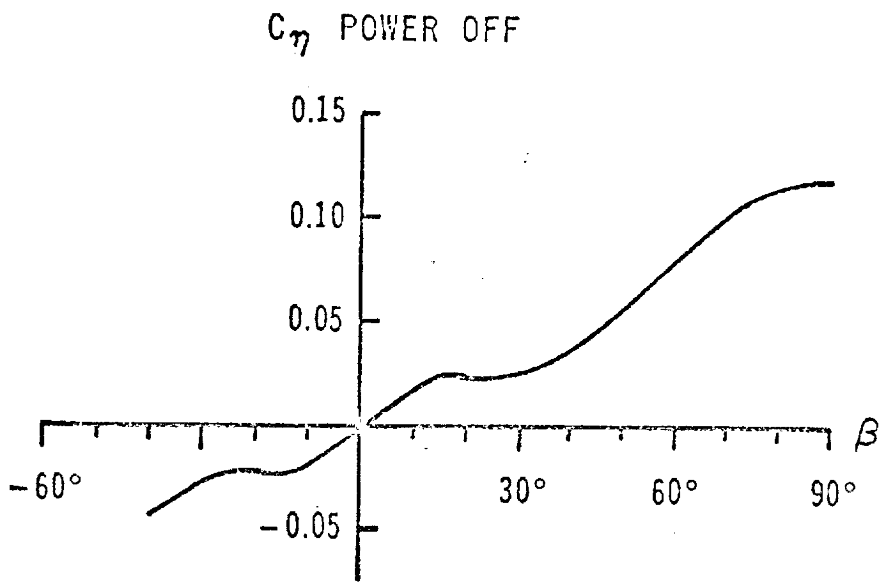


Figure A - 1 - 7 C_η Power Off vs. β

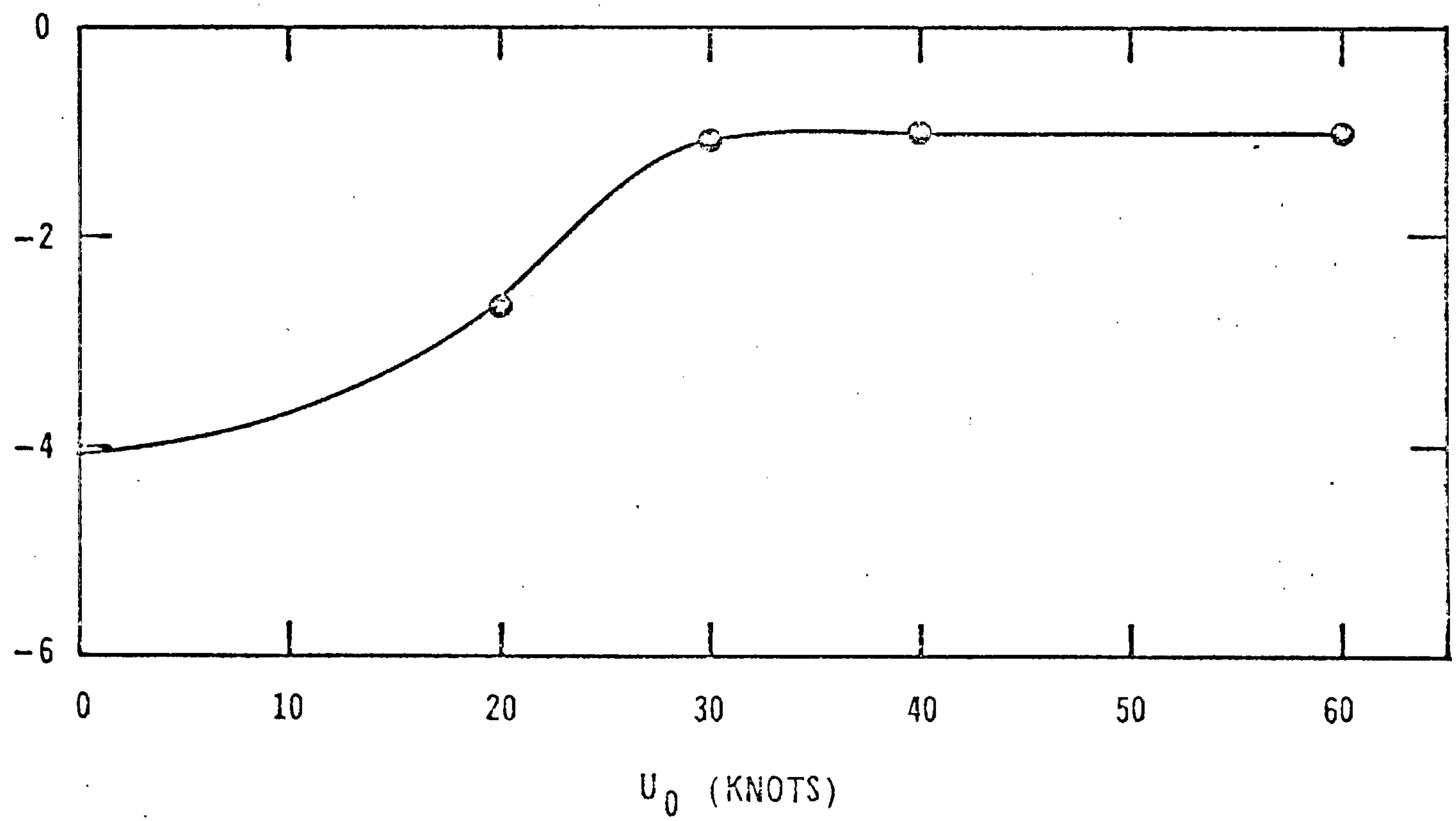


Figure A – 1 – 8 C_{M_α} Power Off

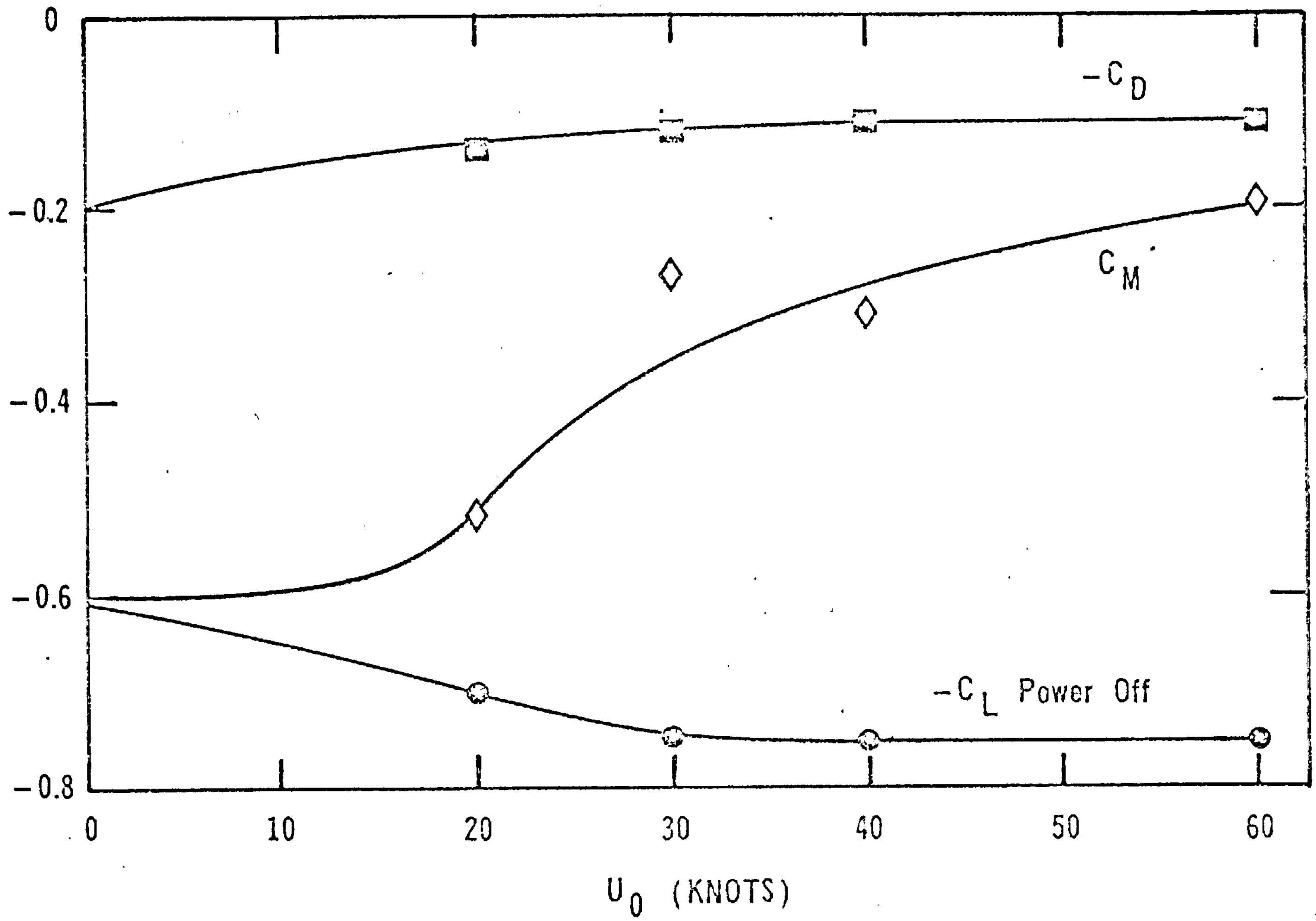


Figure A-1-9 C_D, C_M and C_L vs. U_0

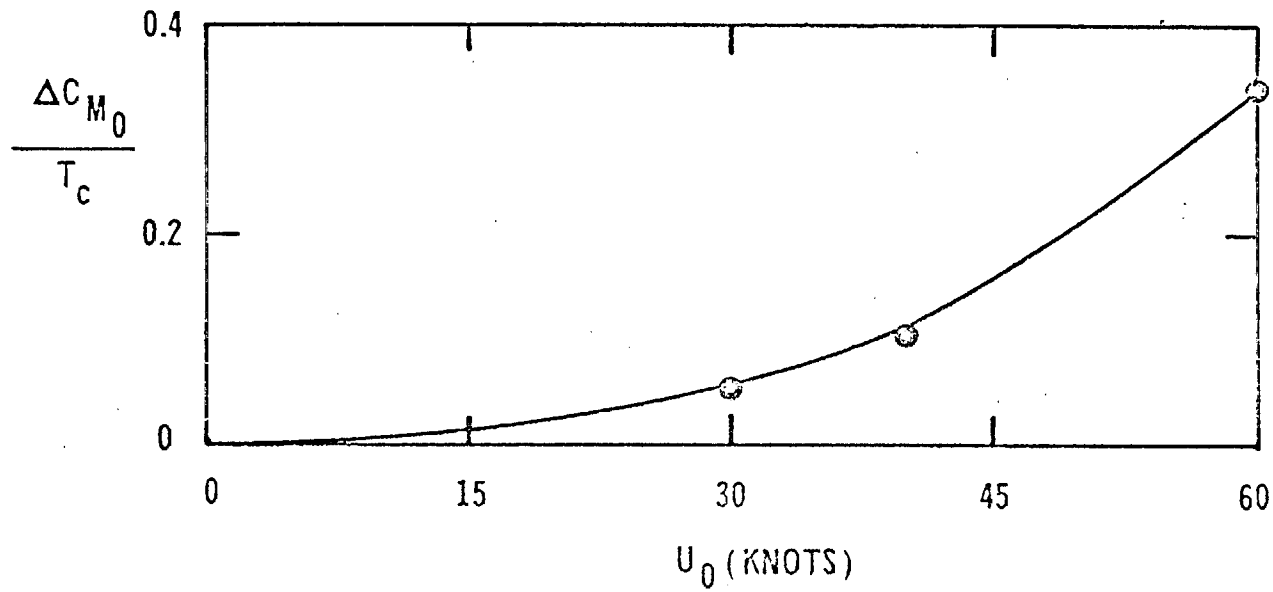


Figure A – 1 – 10 Pitching Moment Interference

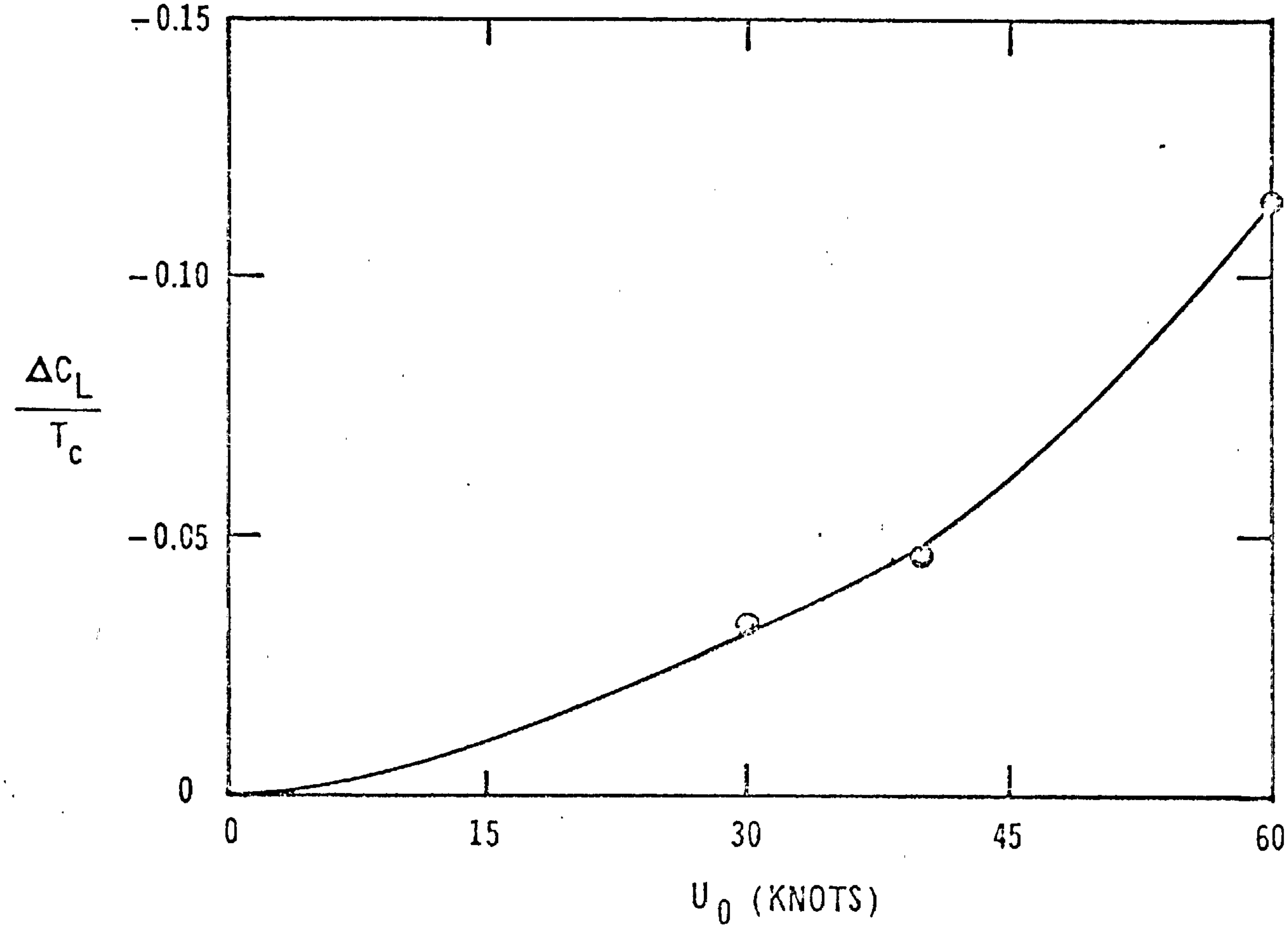


Figure A – 1 – 11 Lift Interference

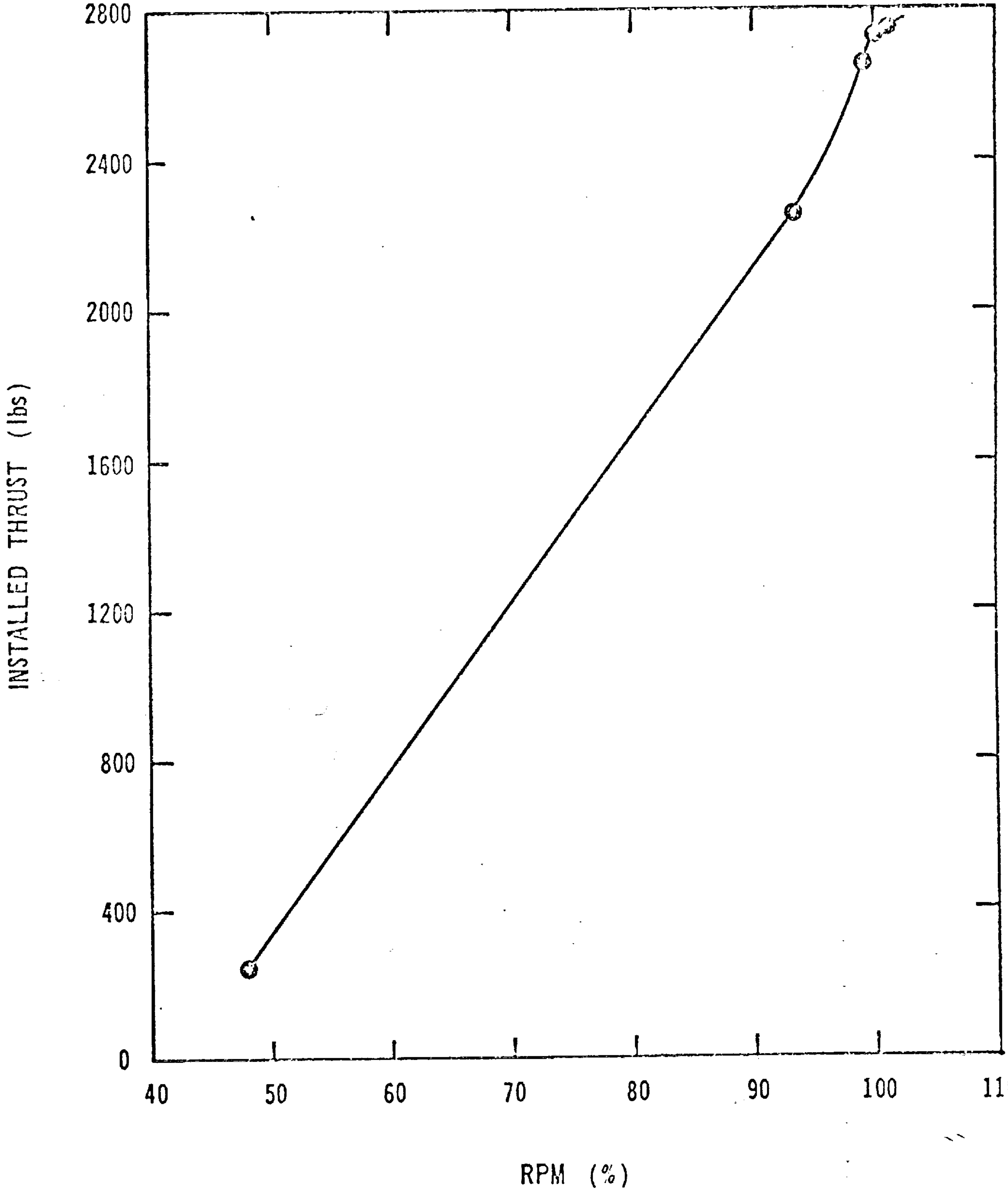


Figure A – 1 – 12 Installed Thrust vs. RPM

D. Solution of the X-14 Equations of Motion for the Reference Control Variables

The reference values for the elements of the control vector $\underline{u}$ are desired for any given state vector $\underline{x}$. Since a steady state reference condition is sought, set $\underline{\dot{x}} = \underline{0}$. Upon examination of the non-linear equations of motion for the X-14 (see Fig. A-1-4, page), it is seen that $\dot{u}$, $\dot{v}$, and $\dot{w}$ are only functions of T, σ and λ . Therefore, an explicit solution for these variables should exist since there are three equations and three unknowns. To find this solution, first rewrite the equations as

$$
\begin{aligned}
0 &= A + T\,(\sin\sigma\,\cos\lambda - u_{rel}/V_j + f\,\sin\alpha)\\
0 &= B + T\,(\sin\lambda - v_{rel}/V_j)\\
0 &= C - T\,(\cos\sigma\,\cos\lambda + w_{rel}/V_j + f\,\cos\alpha\,)
\end{aligned}
\qquad \text{(A-1-14)}
$$

where

$$A = m\,(vr - wq - g\,\sin\theta) + 1/2\;\rho\,U_0^{\,2}\,S\,(C_{L_{\text{power off}}}\sin\alpha - C_D\cos\alpha\,)$$

$$B = m\,(wp - ur + g\,\sin\phi\,\cos\theta) + 1/2\,\rho\,\bar{U}_0^{\,2}\,S\,C_Y$$

$$C = m\,(uq - vp + g\,\cos\phi\,\cos\theta) - 1/2\,\rho U_0^{\,2}\,S\,(C_{L_{\text{power off}}}\cos\alpha + C_D\,\sin\alpha)$$

$$f = \Delta C_L/T_C$$

After squaring, rearranging and adding equations, the result can be written as

$$DT^2 + 2\,ET - F = 0$$

where

$$D = 1 - \bar{U}_0^{\,2}/V_j^{\,2} - f^2 + 2f\,(u_{rel}\,\sin\alpha - w_{rel}\,\cos\alpha)/V_j$$

$$E = (A\,u_{rel} + B\,v_{rel} + C\,w_{rel})/V_j - f\,(A \sin\alpha - C \cos\alpha)$$

$$F = A^2 + B^2 + C^2 \tag{A-1-15}$$

Hence,

$$T = (-E + \sqrt{E^2 + DF}\,)/D. \tag{A-1-16}$$

Now since T is known,

$$\lambda = \sin^{-1}\,(v_{rel}/V_j - B/T) \tag{A-1-17}$$

and now from Eqn. (A-1-14),

$$\sigma = \sin^{-1}\,[(u_{rel}/V_j - f \sin\alpha - A/T)/\cos\lambda]. \tag{A-1-18}$$

Some additional information is needed to solve the moment equations since there are six unknowns and only three equations. Since both the three reaction controls and the three aerodynamic controls have approximately the same range of travel, let us assume for determining the control settings for reference flight conditions that the aerodynamic and the reaction controls are of the same magnitude, or that

$$\delta_x = \delta_a$$

$$\delta_y = \delta_e$$

$$\delta_z = \delta_r$$

When the above numerically determined values of T, λ and σ are substituted into the summary equations for the X-14, the equations can be solved for δ_z, δ_e, δ_r, δ_x, δ_y, and δ_z. The results are

$$\delta_x = \delta_a = -\{(I_y - I_z)\,qr + I_{xz}\,pq + T[-\sin\lambda\,(z_2 + \ell_1 \cos\sigma)$$

$$+ z_1\,v_{rel}/V_j] + L_p\,p + 1/2\,\rho\,\bar{U}_0^{\,2}\,Sb\,C_{\ell_0}\,\}\,/(L_{\delta_x} \tag{A-1-19}$$

$$+ 1/2\,\rho\,\bar{U}_0^{\,2}\,Sb\,C_{\ell_{\delta_a}}\,)$$

$$\delta_y = \delta_e = - \{ (I_z - I_x) pr + I_{xz} (r^2 - p^2) - 2 I_e \Omega_e r$$

$$+ T [\cos\lambda (z_2 \sin \sigma + x_2 \cos\sigma) + (x_1 w_{rel} - z_1 u_{rel})/V_j]$$

$$+ M_q q + 1/2 \rho U_0^2 Sc [(C_{m_{0_{\text{power off}}}} + \Delta C_{m_0})$$

$$+ (C_{m_{\alpha_{\text{power off}}}} + \Delta C_{m_\alpha}) \alpha + \frac{c}{2U_0} C_{m_q} q] \} / (M_{\delta_y} \tag{A-1-20}$$

$$+ 1/2 \rho U_0^2 Sc C_{m_{\delta_e}})$$

$$\delta_z = \delta_r = - \{ (I_x - I_y) pq - I_{xz} qr + 2 I_e \Omega_e q + N_r r$$

$$+ T [\sin \lambda (x_2 - \ell_2 \sin \sigma) - x_1 v_{rel}/V_j] + 1/2 \rho \bar{U}_0^2 Sb (C_{n_0}$$

$$+ C_{n_{\delta_a}} \delta_a) \} / (N_{\delta_z} + 1/2 \rho \bar{U}_0^2 Sb C_{n_{\delta_r}}) \tag{A-1-21}$$

CHAPTER I

References for Chapter I

1. Etkin, B., Dynamics of Flight, John Wiley & Sons, Inc., New York, 1959.

2. Seckel, E., Stability and Control of Airplanes and Helicopters, Academic Press, New York, 1964.

3. Dommasch, D., Sherby, S. and Connolly, T., Airplane Aerodynamics, Pitman Publishing Corp., New York, 1961.

4. Struke, E., "Interactive Graphics in Aircraft Landing and Take-Off Studies," Proc. of the Conf. on Applications of Continuous System Simulation Languages, San Francisco, Calif., June 30-July 1, 1969.

5. Sinacori, J., "Variable Stability System for a VTOL Aircraft," Northrop Norair Report NOR 68-21, 1968.

CHAPTER II

LINEARIZATION OF NON-LINEAR EQUATIONS OF MOTION FOR A TIME INVARIANT DYNAMIC SYSTEM

The non-linear equations of motion for a time invariant dynamic system can be expressed as:

$$\underline{\dot{x}} = \underline{f}\ (\underline{x},\ \underline{u}) \tag{A-2-1}$$

where $\underline{x}$ is the state vector, $\underline{u}$ is the control vector, and $\underline{f}$ is a vector function of $\underline{x}$ and $\underline{u}$ [1].

Suppose that for the system represented by Eqn. (A-2-1) there is a given $\underline{x}\ (t_0) = \underline{x}_0$ and $\underline{u}\ (t)$ for $t > t_0$, then the unique solution $\phi\ (t,\ \underline{x}_0)$ is determined and can be found. Now consider small perturbations $\delta\underline{x}\ (t_0)$ in $\underline{x}_0$ and $\delta\underline{u}\ (t)$ in $\underline{u}\ (t)$. Hence, small perturbations in the solution $\phi\ (t,\ \underline{x}_0)$ can be expected and

$$\underline{\dot{x}} + \delta\underline{\dot{x}} = \underline{f}\ (\underline{x} + \delta\underline{x},\ \underline{u} + \delta\underline{u});\quad \delta\underline{x}\ (t_0) = \delta\underline{x}_0 \tag{A-2-2}$$

Expanding the right-hand side of Eqn. (A-2-2) in a Taylor series and retaining terms only of the first order, and after substituting equation A-2-1 for $\underline{\dot{x}}$, we have the variational equation

$$\delta\underline{\dot{x}} = \underline{A}\ \delta\underline{x} + \underline{B}\ \delta\underline{u};\quad \delta\underline{x}\ (t_0) = \delta\underline{x}_0 \tag{A-2-3}$$

where

$$A_{ij} = \frac{\partial f_i}{\partial x_j} \qquad B_{ij} = \frac{\partial f_i}{\partial u_j} \tag{A-2-4}$$

with the partial derivatives being evaluated along the known solution, $\underline{x}\ (t) = \phi\ (t,\ \underline{x}_0)$ and control $\underline{u}\ (t)$. Hence, the motion of the dynamic system about a known path for a small perturbation is seen to be governed by the linear ordinary differential equations (A-2-3) and (A-2-4).

The numerical evaluation of the partial derivatives in equation (A-2-4) can be accomplished by using the central difference approximation. [2] A review of this method follows. The Taylor series for the function f_i expanded about $(\underline{x}_0 + \Delta\underline{x}, \underline{u}_0)$ with

$$(\Delta\underline{x})^T = (0 \ldots 0 \quad x_j \quad 0 \ldots 0)$$

is

$$f_i\ (\underline{x}_0 + \Delta\underline{x}, \underline{u}_0) = f_i\ (\underline{x}_0, \underline{u}_0) + \frac{\partial f_i}{\partial x_j} \Delta x_j + 1/2 \frac{\partial^2 f_i}{\partial x_j{}^2} \Delta x_j{}^2 + \ldots \qquad \text{(A-2-5)}$$

with $\frac{\partial f_i}{\partial x_j}$ evaluated at $(\underline{x}_0, \underline{u}_0)$. Similarly, the function expanded about $(\underline{x}_0 - \Delta\underline{x}, \underline{u}_0)$ is given by

$$f_i\ (\underline{x}_0 - \ \underline{x}, \underline{u}_0) = f_i\ (\underline{x}_0, \underline{u}_0) - \frac{\delta f_i}{\partial x_j}\ x_j + 1/2 \frac{\partial^2 f_i}{\partial x_j{}^2} \Delta x_j{}^2 + \ldots \qquad \text{(A-2-6)}$$

Since Δx is small, $(\Delta x_j)^3$ and higher order terms are neglected. If equation (A-2-6) is subtracted from (A-2-5), and the resulting equation solved for the partial derivative evaluated at the point $(\underline{x}_0, \underline{u}_0)$ with $\Delta x_k = 0$ for $k \neq j$, the result is

$$A_{ij} = \frac{\partial f_i}{\partial x_j} = \frac{f_i(\underline{x}_0 + \Delta\underline{x}, \underline{u}_0) - f_i\ (\underline{x}_0 - \Delta\underline{x}, \underline{u}_0)}{2\Delta x_j} \qquad \text{(A-2-7)}$$

In a similar manner the elements of $\underline{B}$ are found to be

$$B_{ij} = \frac{\partial f_i}{\partial u_j} = \frac{f_i\ (\underline{x}_0, \underline{u}_0 + \Delta\underline{u}) - f_i\ (\underline{x}_0, \underline{u}_0 - \Delta\underline{u})}{2(\Delta u_j)} \qquad \text{(A-2-8)}$$

where $(\Delta\underline{u})^T = (0 \quad 0 \quad 0 \quad \ldots \quad \Delta u_j \quad 0 \quad . \ . \ . \quad 0)$.

A digital computer program that performs the above operations and its description can be found in Appendix A III.

CHAPTER II

References for Chapter II

1. Bryson, A. E., Jr., and Y. C. Ho, Applied Optimal Control, Blaisdell Publishing Co., Waltham, Mass., 1969.

2. James, M. L., G. M. Smith, and J. C. Wolford, Analog and Digital Computer Methods in Engineering Analysis, International Textbook Co., Scranton, Penn., 1964.

CHAPTER III

TRIM PARAMETERS AND STABILITY DERIVATIVES FOR THE X-14

The numerical values for the trim parameters can be determined for any reference flight condition using equations (A-1-14) through (A-1-21). In addition, the stability derivatives can be calculated using the linearization method of Chapter II and the equations of motion for the X-14 of Chapter I.

Trim parameters and stability derivatives for thirty flight conditions are shown in Tables A-3-1 to A-3-30. These were calculated on a digital computer using the FORTRAN IV programs of Appendix V. The reference conditions are for wings level and forward velocities ranging from -10 feet per second to +169 feet per second. The verticle velocity ranges from -10 to +10 feet per second and the horizontal lateral velocity goes from zero to +15 feet per second.

The zero forward velocity condition is represented by a numerical value of 0.01 feet per second which was necessitated because of the non-dimensionalization method used. If $u = 0$, then certain segments of the equations of motion could require division by zero. Any error that might be introduced by this approximation is trivial for the conditions being investigated in this paper.

The "A Matrix" represents the relationship between the time derivatives of the state variables and the state variables as listed in the reference condition column. The "B Matrix" is the relationship between the state variables and the control variables as listed in the trim parameter column. The "Wind Disturbance Matrix" represents the effect of wind disturbances on the state variables. The columns of the wind matrix are for the X, Y and Z directions, respectively.

TABLE A-3- 1 FLIGHT CONDITION 1

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = -10.00 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -1.41 DEGREES
REACTION NOZZLE DY = -1.41 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = -0.32 DEGREES
ENGINE RPM = 98.87 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.262575	-0.003918	-0.006804	0.000000	0.000000	0.000000	-0.502503
-32.035897	0.000000	-0.015943	-0.024694	0.000000	0.000000	0.000000	0.000000
0.000000	-10.000000	-0.007581	-0.022676	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024400	0.000000	0.000000	0.000000	-0.451157	-0.001275	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.043598	10.000000
0.000000	0.317204	0.000000	0.000000	0.000000	-0.015039	-0.001697	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000632	0.034907	0.019831	-0.007687	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.566401	-0.002609	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.003133	3.591567	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000943	0.000012	-0.034157	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.566410	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000012	0.000161	-0.001308	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.003918	0.000000	0.007953
0.015943	0.000000	0.023151
0.007581	0.000000	0.022851
0.000000	0.000000	0.000000
0.000000	0.000459	0.000000
0.000000	0.031845	0.000000
0.000000	0.002194	0.000000

TABLE A-3- 2 FLIGHT CONDITION 2

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 0.01 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 0.47 DEGREES
REACTION NOZZLE DY = 0.47 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.00 DEGREES
ENGINE RPM = 98.57 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.150113	-0.000436	-0.000147	0.000000	0.000000	0.000000	-0.500992
-32.035897	0.000000	-0.020130	-0.038363	0.000000	0.000000	0.000000	0.000000
0.000000	0.010000	0.000050	-0.020819	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024327	0.000000	0.000000	0.000000	-0.451157	0.000306	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.022425	-0.010000
0.000000	0.316251	0.000000	0.000000	0.000000	-0.015039	-0.002452	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000000	0.034907	0.019679	0.001822	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.562003	-0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000004	3.600197	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.033893	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.562003	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.001310	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000436	0.000000	0.004629
0.020130	0.000000	0.033862
-0.000050	0.000000	0.021405
0.000000	0.000000	0.000000
0.000000	-0.000183	0.000000
0.000000	0.024725	0.000000
0.000000	0.002014	0.000000

TABLE A-3- 3 FLIGHT CONDITION 3

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 0.01 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 5.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 0.47 DEGREES
REACTION NOZZLE DY = 0.47 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.00 DEGREES
ENGINE RPM = 98.58 PERCENT OF MAXIMUM
AILERONS = 0.08 DEGREES
RUDDER = 0.61 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.22 DEGREES
REACTION NOZZLE DX = 0.08 DEGREES
REACTION NOZZLE DZ = 0.61 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.150113	-0.000436	-0.000147	0.000000	0.000000	0.000000	-0.500994
-32.035897	0.000000	-0.020130	-0.038363	0.000000	0.000000	0.000000	5.000000
0.000000	0.010000	0.000050	-0.020819	0.000000	-5.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024327	-0.000001	0.000000	0.000000	-0.451157	-0.000064	-0.015424
0.000000	0.000000	-0.000007	0.000000	31.832873	0.000000	-0.029324	-0.010000
0.000000	0.316251	-0.000001	0.000000	0.000000	-0.015039	-0.001137	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000000	0.034907	0.019679	0.001822	0.000000	0.000000	0.000001	0.000000	0.000000
0.000000	0.000000	0.562003	-0.000000	0.000000	0.000000	-0.000000	0.000000	0.000000
0.000000	0.000000	0.000004	3.600200	0.000000	0.000000	0.002158	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.000001	0.000594	0.000000	0.000000	-0.033893	0.068243	0.001279
0.000000	0.000000	0.000000	-0.002571	0.000000	0.000000	0.562003	0.000000	0.000000
0.000000	0.000000	-0.000009	0.001648	0.000000	0.000000	-0.001310	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000436	0.000000	0.004629
0.020130	0.000000	0.033863
-0.000050	0.000000	0.021405
0.000000	0.000000	0.000000
0.000001	0.000064	0.000000
0.000007	0.029324	0.000000
0.000001	0.001137	0.000000

TABLE A-3- 4 FLIGHT CONDITION 4

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	0.01 FT/SEC
W =	0.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	15.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	0.47 DEGREES
REACTION NOZZLE DY =	0.47 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	0.00 DEGREES
ENGINE RPM =	98.58 PERCENT OF MAXIMUM
AILERONS =	0.51 DEGREES
RUDDER =	0.24 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.91 DEGREES
REACTION NOZZLE DX =	0.51 DEGREES
REACTION NOZZLE DZ =	0.24 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.150113	-0.000436	-0.000146	0.000000	0.000000	0.000000	-0.501016
-32.035897	0.000000	-0.020133	-0.038368	0.000000	0.000000	0.000000	15.000000
0.000000	0.010000	0.000050	-0.020822	0.000000	-15.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024328	-0.000000	0.000000	0.000000	-0.451157	-0.001050	-0.015424
0.000000	0.000000	-0.000018	0.000000	31.832873	0.000000	-0.047724	-0.010000
0.000000	0.316266	-0.000003	0.000000	0.000000	-0.015039	0.002368	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000000	0.034907	0.019679	0.001822	0.000000	0.000000	0.000005	0.000000	0.000000
0.000000	0.000000	0.562003	-0.000000	0.000000	0.000000	-0.000000	0.000000	0.000000
0.000000	0.000000	0.000004	3.600250	0.000000	0.000000	0.008882	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.000003	0.002711	0.000000	0.000000	-0.033893	0.068243	0.001279
0.000000	0.000000	0.000000	-0.023141	0.000000	0.000000	0.562003	0.000000	0.000000
0.000000	0.000000	-0.000036	0.004980	0.000000	0.000000	-0.001310	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000436	0.000000	0.004628
0.020133	0.000000	0.033867
-0.000050	0.000000	0.021407
0.000000	0.000000	0.000000
0.000000	0.001050	0.000000
0.000018	0.047724	0.000000
0.000003	-0.002368	0.000000

TABLE A-3- 5 FLIGHT CONDITION 5

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 0.01 FT/SEC
W = 5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -0.24 DEGREES
REACTION NOZZLE DY = -0.24 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.30 DEGREES
ENGINE RPM = 98.45 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.206288	-0.000446	-0.006683	0.000000	0.000000	0.000000	-0.500356
-32.035897	-5.000000	-0.020051	-0.024796	0.000000	0.000000	0.000000	0.000000
0.000000	0.010000	0.000046	-0.022456	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024296	0.000000	0.000000	0.000000	-0.451157	-0.000018	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	5.000000	-0.025840	-0.010000
0.000000	0.315849	0.000000	0.000000	0.000000	-0.015039	-0.002521	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000158	0.034907	0.019615	-0.006673	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.560140	0.002914	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.002948	3.598068	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000236	0.000003	-0.033782	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.560147	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000003	0.000040	-0.001317	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000446	0.000000	0.006182
0.020051	0.000000	0.024845
-0.000046	0.000000	0.022408
0.000000	0.000000	0.000000
0.000000	-0.000015	0.000000
0.000000	0.026632	0.000000
0.000000	0.002244	0.000000

TABLE A-3- 6 FLIGHT CONDITION 6

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 0.01 FT/SEC
W = -5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -1.23 DEGREES
REACTION NOZZLE DY = -1.23 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = -0.30 DEGREES
ENGINE RPM = 98.70 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.206288	-0.000437	-0.019757	0.000000	0.000000	0.000000	-0.501637
-32.035897	5.000000	-0.020210	-0.025027	0.000000	0.000000	0.000000	0.000000
0.000000	0.010000	0.000049	-0.022554	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024358	0.000000	0.000000	0.000000	-0.451157	-0.000015	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-5.000000	-0.025974	-0.010000
0.000000	0.316657	0.000000	0.000000	0.000000	-0.015039	-0.002540	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000158	0.034907	0.019743	-0.000215	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.563876	-0.002919	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.002963	3.602323	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000236	0.000003	-0.034005	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.563883	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000003	0.000040	-0.001302	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000437	0.000000	0.019391
0.020210	0.000000	0.025077
-0.000049	0.000000	0.022506
0.000000	0.000000	0.000000
0.000000	-0.000017	0.000000
0.000000	0.026766	0.000000
0.000000	0.002263	0.000000

TABLE A-3- 7 FLIGHT CONDITION 7

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 0.01 FT/SEC
W = 10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 2.04 DEGREES
REACTION NOZZLE DY = 2.04 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.44 DEGREES
ENGINE RPM = 98.31 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.262575	-0.000444	-0.024807	0.000000	0.000000	0.000000	-0.499662
-32.035897	-10.000000	-0.019977	-0.007103	0.000000	0.000000	0.000000	0.000000
0.000000	0.010000	0.000036	-0.024353	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024262	0.000000	0.000000	0.000000	-0.451157	-0.001282	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	10.000000	-0.043301	-0.010000
0.000000	0.315411	0.000000	0.000000	0.000000	-0.015039	-0.001654	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000632	0.034907	0.019545	-0.013841	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.558105	0.011911	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.004317	3.594626	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000943	0.000012	-0.033660	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.558122	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000012	0.000161	-0.001318	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000444	0.000000	0.024295
0.019977	0.000000	0.007151
-0.000036	0.000000	0.024344
0.000000	0.000000	0.000000
0.000000	0.000465	0.000000
0.000000	0.031549	0.000000
0.000000	0.002151	0.000000

TABLE A-3- 8 FLIGHT CONDITION 8

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	0.01 FT/SEC
W =	-10.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	0.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	-4.90 DEGREES
REACTION NOZZLE DY =	-4.90 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	-0.45 DEGREES
ENGINE RPM =	98.84 PERCENT OF MAXIMUM
AILERONS =	0.00 DEGREES
RUDDER =	0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.00 DEGREES
REACTION NOZZLE DX =	0.00 DEGREES
REACTION NOZZLE DZ =	0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.262575	-0.000448	-0.031412	0.000000	0.000000	0.000000	-0.502349
-32.035897	10.000000	-0.020289	-0.007505	0.000000	0.000000	0.000000	0.000000
0.000000	0.010000	0.000040	-0.024598	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024393	0.000000	0.000000	0.000000	-0.451157	-0.001276	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-10.000000	-0.043582	-0.010000
0.000000	0.317107	0.000000	0.000000	0.000000	-0.015039	-0.001695	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000632	0.034907	0.019815	-0.001693	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.565944	-0.011936	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.004396	3.605764	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000943	0.000012	-0.034130	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.565961	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000012	0.000161	-0.001302	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.000448	0.000000	0.031057
0.020289	0.000000	0.007555
-0.000040	0.000000	0.024589
0.000000	0.000000	0.000000
0.000000	0.000459	0.000000
0.000000	0.031829	0.000000
0.000000	0.002191	0.000000

TABLE A-3- 9 FLIGHT CONDITION 9

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 10.00 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -1.56 DEGREES
REACTION NOZZLE DY = -1.56 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.40 DEGREES
ENGINE RPM = 98.87 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.262575	0.003033	-0.006804	0.000000	0.000000	0.000000	-0.502504
-32.035897	0.000000	-0.024623	-0.024694	0.000000	0.000000	0.000000	0.000000
0.000000	10.000000	0.007581	-0.022677	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024400	0.000000	0.000000	0.000000	-0.451157	-0.001275	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.043598	-10.000000
0.000000	0.317205	0.000000	0.000000	0.000000	-0.015039	-0.001697	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000632	0.034907	0.019835	-0.008265	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.566401	-0.002609	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.003947	3.591571	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000943	0.000012	-0.034160	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.566415	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000012	0.000161	-0.001336	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.003033	0.000000	0.007953
0.024623	0.000000	0.023151
-0.007581	0.000000	0.022852
0.000000	0.000000	0.000000
0.000000	0.000459	0.000000
0.000000	0.031845	0.000000
0.000000	0.002194	0.000000

TABLE A-3-10 FLIGHT CONDITION 10

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	10.00 FT/SEC
W =	0.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	10.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	-1.56 DEGREES
REACTION NOZZLE DY =	-1.56 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	0.40 DEGREES
ENGINE RPM =	98.87 PERCENT OF MAXIMUM
AILERONS =	0.33 DEGREES
RUDDER =	0.98 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.59 DEGREES
REACTION NOZZLE DX =	0.33 DEGREES
REACTION NOZZLE DZ =	0.98 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.262575	0.003034	-0.006804	0.000000	0.000000	0.000000	-0.502515
-32.035897	0.000000	-0.024624	-0.024696	0.000000	0.000000	0.000000	10.000000
0.000000	10.000000	0.007583	-0.022678	0.000000	-10.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024401	-0.000623	0.000000	0.000000	-0.451157	-0.000526	-0.015424
0.000000	0.000000	-0.006827	0.000000	31.832873	0.000000	-0.039549	-10.000000
0.000000	0.317212	-0.000568	0.000000	0.000000	-0.015039	0.000210	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000632	0.034907	0.019835	-0.008266	0.000000	0.000000	0.000002	0.000000	0.000000
0.000000	0.000000	0.566401	-0.002609	0.000000	0.000000	-0.000041	0.000000	0.000000
0.000000	0.000000	0.003947	3.591593	0.000000	0.000000	0.005835	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.000001	0.001772	0.000943	0.000012	-0.034160	0.068243	0.001279
0.000000	0.000000	0.000000	-0.014712	0.000000	0.000000	0.566415	0.000000	0.000000
0.000000	0.000000	-0.000023	0.003348	0.000012	0.000161	-0.001336	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.003034	0.000000	0.007953
0.024624	0.000000	0.023153
-0.007583	0.000000	0.022853
0.000000	0.000000	0.000000
0.000623	0.000549	0.000000
0.006827	0.039749	0.000000
0.000568	0.000029	0.000000

TABLE A-3-11 FLIGHT CONDITION 11

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 10.00 FT/SEC
W = 5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -0.60 DEGREES
REACTION NOZZLE DY = -0.60 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.61 DEGREES
ENGINE RPM = 98.71 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.275863	-0.001981	-0.010056	0.000000	0.000000	0.000000	-0.501696
-32.035897	-5.000000	-0.016850	-0.019624	0.000000	0.000000	0.000000	0.000000
0.000000	10.000000	0.006319	-0.030974	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024361	0.000000	0.000000	0.000000	-0.451157	-0.001706	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	5.000000	-0.049862	-10.000000
0.000000	0.316695	0.000000	0.000000	0.000000	-0.015039	-0.001400	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000790	0.034907	0.019753	-0.012205	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.564024	0.003830	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.005981	3.586901	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.001179	0.000015	-0.034018	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.564056	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000015	0.000201	-0.001339	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.001981	0.000000	0.010910
0.016850	0.000000	0.018626
-0.006319	0.000000	0.030637
0.000000	0.000000	0.000000
0.000000	0.000665	0.000000
0.000000	0.033290	0.000000
0.000000	0.002039	0.000000

TABLE A-3-12 FLIGHT CONDITION 12

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 10.00 FT/SEC
W = -5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -2.72 DEGREES
REACTION NOZZLE DY = -2.72 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.20 DEGREES
ENGINE RPM = 98.98 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.275863	0.005705	-0.012297	0.000000	0.000000	0.000000	-0.503067
-32.035897	5.000000	-0.032415	-0.018114	0.000000	0.000000	0.000000	0.000000
0.000000	10.000000	0.008277	-0.015644	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024428	0.000000	0.000000	0.000000	-0.451157	-0.001703	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-5.000000	-0.050005	-10.000000
0.000000	0.317560	0.000000	0.000000	0.000000	-0.015039	-0.001421	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000790	0.034907	0.019892	-0.006171	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.568054	-0.009583	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.001969	3.592745	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.001179	0.000015	-0.034258	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.568057	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000015	0.000201	-0.001332	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.005705	0.000000	0.012735
0.032415	0.000000	0.017219
-0.008277	0.000000	0.016191
0.000000	0.000000	0.000000
0.000000	0.000662	0.000000
0.000000	0.033434	0.000000
0.000000	0.002059	0.000000

TABLE A-3-13 FLIGHT CONDITION 13

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 20.00 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -1.96 DEGREES
REACTION NOZZLE DY = -1.96 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.87 DEGREES
ENGINE RPM = 98.76 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.375150	-0.001513	-0.014664	0.000000	0.000000	0.000000	-0.501932
-32.035897	0.000000	-0.028319	-0.007426	0.000000	0.000000	0.000000	0.000000
0.000000	20.000000	-0.026590	-0.024535	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024373	0.000000	0.000000	0.000000	-0.451157	-0.004610	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.082783	-20.000000
0.000000	0.316844	0.000000	0.000000	0.000000	-0.015039	0.000035	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.002529	0.034907	0.019777	-0.015868	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.564681	-0.009580	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.008554	3.552470	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.003772	0.000050	-0.034060	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.564746	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000050	0.000644	-0.001351	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.001513	0.000000	0.015110
0.028319	0.000000	0.006637
0.026590	0.000000	0.024623
0.000000	0.000000	0.000000
0.000000	0.002985	0.000000
0.000000	0.066853	0.000000
0.000000	0.000473	0.000000

TABLE A-3-14 FLIGHT CONDITION 14

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 20.00 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 10.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -1.96 DEGREES
REACTION NOZZLE DY = -1.96 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 0.87 DEGREES
ENGINE RPM = 98.76 PERCENT OF MAXIMUM
AILERONS = 0.54 DEGREES
RUDDER = 0.84 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.77 DEGREES
REACTION NOZZLE DX = 0.54 DEGREES
REACTION NOZZLE DZ = 0.84 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.375150	-0.001512	-0.014663	0.000000	0.000000	0.000000	-0.501950
-32.035697	0.000000	-0.028321	-0.007429	0.000000	0.000000	0.000000	10.000000
0.000000	20.000000	-0.026589	-0.024537	0.000000	-10.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024373	-0.001247	0.000000	0.000000	-0.451157	-0.000329	-0.015424
0.000000	0.000000	-0.015836	0.000000	31.832873	0.000000	-0.034840	-20.000000
0.000000	0.316855	0.001206	0.000000	0.000000	-0.015039	-0.002331	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.002529	0.034907	0.019777	-0.015870	0.000000	0.000000	-0.000000	0.000000	0.000000
0.000000	0.000000	0.564682	-0.009580	0.000000	0.000000	-0.000115	0.000000	0.000000
0.000000	0.000000	0.008555	3.552508	0.000000	0.000000	0.007565	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	-0.000001	0.002442	0.003772	0.000050	-0.034060	0.068243	0.001279
0.000000	0.000000	0.000000	-0.025670	0.000000	0.000000	0.564747	0.000000	0.000000
0.000000	0.000000	-0.000030	0.003365	0.000050	0.000644	-0.001351	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.001512	0.000000	0.015110
0.028321	0.000000	0.006640
0.026589	0.000000	0.024624
0.000000	0.000000	0.000000
0.001247	0.000327	0.000000
0.015836	0.032622	0.000000
-0.001206	0.001763	0.000000

TABLE A-3-15 FLIGHT CONDITION 15

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	20.00 FT/SEC
W =	5.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	0.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	0.40 DEGREES
REACTION NOZZLE DY =	0.40 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	0.93 DEGREES
ENGINE RPM =	98.59 PERCENT OF MAXIMUM
AILERONS =	0.00 DEGREES
RUDDER =	0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.00 DEGREES
REACTION NOZZLE DX =	0.00 DEGREES
REACTION NOZZLE DZ =	0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.382079	-0.005357	-0.016916	0.000000	0.000000	0.000000	-0.501060
-32.035897	-5.000000	-0.019937	-0.005117	0.000000	0.000000	0.000000	0.000000
0.000000	20.000000	-0.027575	-0.033031	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024330	0.000000	0.000000	0.000000	-0.451157	-0.004764	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	5.000000	-0.084578	-20.000000
0.000000	0.316293	0.000000	0.000000	0.000000	-0.015039	0.000137	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.002687	0.034907	0.019688	-0.018906	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.562125	0.003019	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.009131	3.546460	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.004008	0.000053	-0.033907	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.562199	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000053	0.000684	-0.001347	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.005357	0.000000	0.017290
0.019937	0.000000	0.004422
0.027575	0.000000	0.032932
0.000000	0.000000	0.000000
0.000000	0.003201	0.000000
0.000000	0.069921	0.000000
0.000000	0.000317	0.000000

TABLE A-3-16 FLIGHT CONDITION 16

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	20.00 FT/SEC
W =	-5.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	0.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	-4.25 DEGREES
REACTION NOZZLE DY =	-4.25 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	0.81 DEGREES
ENGINE RPM =	98.88 PERCENT OF MAXIMUM
AILERONS =	0.00 DEGREES
RUDDER =	0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.00 DEGREES
REACTION NOZZLE DX =	0.00 DEGREES
REACTION NOZZLE DZ =	0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.382079	0.001957	-0.016196	0.000000	0.000000	0.000000	-0.502553
-32.035897	5.000000	-0.036688	-0.003506	0.000000	0.000000	0.000000	0.000000
0.000000	20.000000	-0.025574	-0.016681	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.024403	0.000000	0.000000	0.000000	-0.451157	-0.004760	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-5.000000	-0.084734	-20.000000
0.000000	0.317236	0.000000	0.000000	0.000000	-0.015039	0.000115	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.002687	0.034907	0.019840	-0.013603	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.566500	-0.022714	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.008030	3.554600	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.004008	0.000053	-0.034169	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.566557	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000053	0.000684	-0.001353	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.001957	0.000000	0.016524
0.036688	0.000000	0.002848
0.025574	0.000000	0.016932
0.000000	0.000000	0.000000
0.000000	0.003198	0.000000
0.000000	0.070077	0.000000
0.000000	0.000340	0.000000

TABLE A-3-17 FLIGHT CONDITION 17

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 50.70 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -8.09 DEGREES
REACTION NOZZLE DY = -8.09 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 2.79 DEGREES
ENGINE RPM = 95.99 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.720756	0.014832	-0.003351	0.000000	0.000000	0.000000	-0.487839
-32.035897	0.000000	-0.038175	0.044141	0.000000	0.000000	0.000000	0.000000
0.000000	50.700000	-0.115374	-0.028787	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023688	0.000000	0.000000	0.000000	-0.451157	-0.012268	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.175963	-50.700000
0.000000	0.307948	0.000000	0.000000	0.000000	-0.015039	0.004694	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.016253	0.034907	0.018326	0.010788	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.523008	0.013799	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.025463	-0.786656	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.024241	0.000318	-0.031581	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.523628	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000318	0.004138	-0.001323	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.014832	0.000000	0.003388
0.038175	0.000000	-0.044383
0.115374	0.000000	0.028821
0.000000	0.000000	0.000000
0.000000	0.012330	0.000000
0.000000	0.176725	0.000000
0.000000	-0.004730	0.000000

TABLE A-3-18 FLIGHT CONDITION 18

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 50.70 FT/SEC
W = 5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -6.76 DEGREES
REACTION NOZZLE DY = -6.76 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 2.37 DEGREES
ENGINE RPM = 95.78 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.723524	0.016900	-0.002590	0.000000	0.000000	0.000000	-0.486788
-32.035897	-5.000000	-0.031040	0.044298	0.000000	0.000000	0.000000	0.000000
0.000000	50.700000	-0.115993	-0.035329	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023637	0.000000	0.000000	0.000000	-0.451157	-0.012332	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	5.000000	-0.176613	-50.700000
0.000000	0.307284	0.000000	0.000000	0.000000	-0.015039	0.004746	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.016411	0.034907	0.018223	0.011095	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.520116	0.005144	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.021523	-0.778421	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.024477	0.000321	-0.031396	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.520561	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000321	0.004179	-0.001300	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.016900	0.000000	0.002620
0.031040	0.000000	-0.044534
0.115993	0.000000	0.035327
0.000000	0.000000	0.000000
0.000000	0.012393	0.000000
0.000000	0.177371	0.000000
0.000000	-0.004781	0.000000

TABLE A-3-19 FLIGHT CONDITION 19

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 50.70 FT/SEC
W = -5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -9.66 DEGREES
REACTION NOZZLE DY = -9.66 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 3.21 DEGREES
ENGINE RPM = 96.16 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.723524	0.012666	-0.004609	0.000000	0.000000	0.000000	0.000000
-32.035897	5.000000	-0.045293	0.045932	0.000000	0.000000	0.000000	-0.488705
0.000000	50.700000	-0.113969	-0.022496	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023730	0.000000	0.000000	0.000000	-0.451157	-0.012328	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-5.000000	-0.176814	-50.700000
0.000000	0.308494	0.000000	0.000000	0.000000	-0.015039	0.004717	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.016411	0.034907	0.018410	0.010555	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.525329	0.022537	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.029449	-0.787620	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.024477	0.000321	-0.031732	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.526153	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000321	0.004179	-0.001345	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.012666	0.000000	0.004652
0.045293	0.000000	-0.046162
0.113969	0.000000	0.022565
0.000000	0.000000	0.000000
0.000000	0.012389	0.000000
0.000000	0.177572	0.000000
0.000000	-0.004752	0.000000

TABLE A-3-20 FLIGHT CONDITION 20

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 67.60 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -47.91 DEGREES
REACTION NOZZLE DY = -47.91 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 4.26 DEGREES
ENGINE RPM = 93.43 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.911007	0.054994	-0.006205	0.000000	0.000000	0.000000	-0.474823
-32.035897	0.000000	-0.043037	0.065895	0.000000	0.000000	0.000000	0.000000
0.000000	67.600000	-0.140010	-0.030552	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023056	0.000000	0.000000	0.000000	-0.451157	-0.016508	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.226859	-67.600000
0.000000	0.299731	0.000000	0.000000	0.000000	-0.015039	0.007345	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.028894	0.034907	0.016977	0.017220	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.484310	0.022417	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.036036	-0.667332	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.043096	0.000566	-0.029287	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.485649	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000566	0.007357	-0.001276	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.054994	0.000000	0.006233
0.043037	0.000000	-0.066047
0.140010	0.000000	0.030578
0.000000	0.000000	0.000000
0.000000	0.016554	0.000000
0.000000	0.227431	0.000000
0.000000	-0.007372	0.000000

TABLE A-3-21 FLIGHT CONDITION 21

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 67.60 FT/SEC
W = 5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -41.55 DEGREES
REACTION NOZZLE DY = -41.55 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 3.59 DEGREES
ENGINE RPM = 93.13 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.913086	0.048745	-0.002659	0.000000	0.000000	0.000000	-0.473334
-32.035897	-5.000000	-0.037437	0.065716	0.000000	0.000000	0.000000	0.000000
0.000000	67.600000	-0.140987	-0.036000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.022984	0.000000	0.000000	0.000000	-0.451157	-0.016557	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	5.000000	-0.227306	-67.600000
0.000000	0.298791	0.000000	0.000000	0.000000	-0.015039	0.007389	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.029052	0.034907	0.016867	0.017265	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.481254	0.011651	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.030155	-0.659348	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.043332	0.000569	-0.029080	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.482198	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000569	0.007397	-0.001245	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.048745	0.000000	0.002681
0.037437	0.000000	-0.065866
0.140987	0.000000	0.036006
0.000000	0.000000	0.000000
0.000000	0.016603	0.000000
0.000000	0.227877	0.000000
0.000000	-0.007416	0.000000

TABLE A-3-22 FLIGHT CONDITION 22

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 67.60 FT/SEC
W = -5.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -57.65 DEGREES
REACTION NOZZLE DY = -57.65 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 4.93 DEGREES
ENGINE RPM = 93.63 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.913086	0.064321	-0.011017	0.000000	0.000000	0.000000	-0.475866
-32.035897	5.000000	-0.048611	0.067303	0.000000	0.000000	0.000000	0.000000
0.000000	67.600000	-0.138747	-0.025304	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023107	0.000000	0.000000	0.000000	-0.451157	-0.016552	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832973	-5.000000	-0.227539	-67.600000
0.000000	0.300390	0.000000	0.000000	0.000000	-0.015039	0.007356	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.029052	0.034907	0.017070	0.017305	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.486889	0.033356	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.041959	-0.671865	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.043332	0.000569	-0.029468	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.488694	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000569	0.007397	-0.001307	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.064321	0.000000	0.011051
0.048611	0.000000	-0.067449
0.138747	0.000000	0.025349
0.000000	0.000000	0.000000
0.000000	0.016598	0.000000
0.000000	0.228109	0.000000
0.000000	-0.007383	0.000000

TABLE A-3-23 FLIGHT CONDITION 23

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 67.60 FT/SEC
W = 10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -37.47 DEGREES
REACTION NOZZLE DY = -37.47 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 2.90 DEGREES
ENGINE RPM = 92.72 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.919289	0.044643	0.000164	0.000000	0.000000	0.000000	-0.471261
-32.035897	-10.000000	-0.031966	0.066756	0.000000	0.000000	0.000000	0.000000
0.000000	67.600000	-0.141683	-0.041493	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.022883	0.000000	0.000000	0.000000	-0.451157	-0.016697	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	10.000000	-0.228872	-67.600000
0.000000	0.297482	0.000000	0.000000	0.000000	-0.015039	0.007489	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.029526	0.034907	0.016740	0.017395	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.477712	0.001012	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.024205	-0.646876	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.044039	0.000578	-0.028848	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.478325	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000578	0.007518	-0.001212	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.044643	0.000000	-0.000149
0.031966	0.000000	-0.066897
0.141683	0.000000	0.041479
0.000000	0.000000	0.000000
0.000000	0.016743	0.000000
0.000000	0.229437	0.000000
0.000000	-0.007516	0.000000

TABLE A-3-24 FLIGHT CONDITION 24

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 67.60 FT/SEC
W = -10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -73.10 DEGREES
REACTION NOZZLE DY = -73.10 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 5.61 DEGREES
ENGINE RPM = 93.81 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-0.919289	0.078703	-0.018072	0.000000	0.000000	0.000000	-0.476783
-32.035097	10.000000	-0.054007	0.069890	0.000000	0.000000	0.000000	0.000000
0.000000	67.600000	-0.137216	-0.020409	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.023151	0.000000	0.000000	0.000000	-0.451157	-0.016687	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-10.000000	-0.229339	-67.600000
0.000000	0.300968	0.000000	0.000000	0.000000	-0.015039	0.007422	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.029526	0.034907	0.017148	0.017597	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.489015	0.044665	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.048032	-0.675215	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.044039	0.000578	-0.029626	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.491368	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000578	0.007518	-0.001338	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.078703	0.000000	0.018110
0.054007	0.000000	-0.070024
0.137216	0.000000	0.020471
0.000000	0.000000	0.000000
0.000000	0.016733	0.000000
0.000000	0.229905	0.000000
0.000000	-0.007449	0.000000

TABLE A-3-25 FLIGHT CONDITION 25

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 101.30 FT/SEC
W = 0.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 32.58 DEGREES
REACTION NOZZLE DY = 32.58 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 8.75 DEGREES
ENGINE RPM = 82.97 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-1.290385	-0.005146	-0.012097	0.000000	0.000000	0.000000	-0.421698
-32.035897	0.000000	-0.051862	0.102249	0.000000	0.000000	0.000000	0.000000
0.000000	101.300000	-0.182773	-0.033191	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.020477	0.000000	0.000000	0.000000	-0.451157	-0.024986	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.327547	-101.300000
0.000000	0.266196	0.000000	0.000000	0.000000	-0.015039	0.012757	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.064883	0.034907	0.013380	0.041084	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.381262	0.048292	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.058672	-0.475642	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.096775	0.001271	-0.023240	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.385750	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.001271	0.016520	-0.001134	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.005146	0.000000	0.012116
0.051862	0.000000	-0.102322
0.182773	0.000000	0.033208
0.000000	0.000000	0.000000
0.000000	0.025017	0.000000
0.000000	0.327929	0.000000
0.000000	-0.012775	0.000000

TABLE A-3-26 FLIGHT CONDITION 26

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 101.30 FT/SEC
W = 10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 25.93 DEGREES
REACTION NOZZLE DY = 25.93 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 6.14 DEGREES
ENGINE RPM = 81.93 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-1.295928	0.000719	-0.012465	0.000000	0.000000	0.000000	0.000000
-32.035897	-10.000000	-0.043513	0.102238	0.000000	0.000000	0.000000	-0.416392
0.000000	101.300000	-0.185961	-0.041098	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.020219	0.000000	0.000000	0.000000	-0.451157	-0.025117	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	10.000000	-0.328716	-101.300000
0.000000	0.262847	0.000000	0.000000	0.000000	-0.015039	0.012880	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.065515	0.034907	0.013105	0.041585	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.373686	0.017546	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.040183	-0.481687	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.097718	0.001283	-0.022658	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.375840	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.001283	0.016681	-0.001037	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.000719	0.000000	0.012477
0.043513	0.000000	-0.102310
0.185961	0.000000	0.041098
0.000000	0.000000	0.000000
0.000000	0.025147	0.000000
0.000000	0.329096	0.000000
0.000000	-0.012898	0.000000

TABLE A-3-27 FLIGHT CONDITION 27

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 101.30 FT/SEC
W = -10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = 38.90 DEGREES
REACTION NOZZLE DY = 38.90 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 11.27 DEGREES
ENGINE RPM = 83.96 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-1.295928	-0.010509	-0.010924	0.000000	0.000000	0.000000	-0.426723
-32.035897	10.000000	-0.059962	0.104629	0.000000	0.000000	0.000000	0.000000
0.000000	101.300000	-0.178697	-0.026040	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.020721	0.000000	0.000000	0.000000	-0.451157	-0.025102	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-10.000000	-0.329407	-101.300000
0.000000	0.269368	0.000000	0.000000	0.000000	-0.015039	0.012781	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.065515	0.034907	0.013608	0.041717	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.387515	0.078042	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.077230	-0.467516	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.097718	0.001283	-0.023783	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.395136	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.001283	0.016681	-0.001229	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
0.010509	0.000000	0.010948
0.059962	0.000000	-0.104696
0.178697	0.000000	0.026073
0.000000	0.000000	0.000000
0.000000	0.025132	0.000000
0.000000	0.329787	0.000000
0.000000	-0.012799	0.000000

TABLE A-3-28 FLIGHT CONDITION 28

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	169.00 FT/SEC
W =	0.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	0.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	3.20 DEGREES
REACTION NOZZLE DY =	3.20 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	89.92 DEGREES
ENGINE RPM =	53.40 PERCENT OF MAXIMUM
AILERONS =	0.00 DEGREES
RUDDER =	0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.00 DEGREES
REACTION NOZZLE DX =	0.00 DEGREES
REACTION NOZZLE DZ =	0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-2.052518	0.012213	-0.024595	0.000000	0.000000	0.000000	-0.271399
-32.035897	0.000000	-0.066721	0.190602	0.000000	0.000000	0.000000	0.000000
0.000000	169.000000	-0.350512	-0.035607	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.013178	0.000000	0.000000	0.000000	-0.451157	-0.042085	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	0.000000	-0.527030	-169.000000
0.000000	0.171320	0.000000	0.000000	0.000000	-0.015039	0.024046	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.150587	0.034907	0.000059	0.216448	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000154	0.486455	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.105018	0.326210	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.269350	0.003537	-0.005393	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.105018	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.003537	0.045981	-0.000634	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.012213	0.000000	0.024606
0.066721	0.000000	-0.190655
0.350512	0.000000	0.035618
0.000000	0.000000	0.000000
0.000000	0.042104	0.000000
0.000000	0.527259	0.000000
0.000000	-0.024057	0.000000

TABLE A-3-29 FLIGHT CONDITION 29

REFERENCE CONDITION

THEDA = 0.0 RADIANS
Q = 0.0 RAD/SEC
U = 169.00 FT/SEC
W = 10.00 FT/SEC
PHI = 0.0 RADIANS
P = 0.0 RAD/SEC
V = 0.00 FT/SEC
R = 0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR = -3.66 DEGREES
REACTION NOZZLE DY = -3.66 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) = 68.33 DEGREES
ENGINE RPM = 49.96 PERCENT OF MAXIMUM
AILERONS = 0.00 DEGREES
RUDDER = 0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) = 0.00 DEGREES
REACTION NOZZLE DX = 0.00 DEGREES
REACTION NOZZLE DZ = 0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-2.055846	0.012432	-0.024214	0.000000	0.000000	0.000000	-0.253915
-32.035897	-10.000000	-0.055153	0.196345	0.000000	0.000000	0.000000	0.000000
0.000000	169.000000	-0.375103	-0.044998	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.012330	0.000000	0.000000	0.000000	-0.451157	-0.042184	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	10.000000	-0.526775	-169.000000
0.000000	0.160284	0.000000	0.000000	0.000000	-0.015039	0.024257	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.181219	0.034907	0.000970	0.216903	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.026715	0.428600	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.067250	0.124197	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.270293	0.003549	-0.003961	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.072362	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.003549	0.046142	-0.000425	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.012432	0.000000	0.024224
0.055153	0.000000	-0.196403
0.375103	0.000000	0.045004
0.000000	0.000000	0.000000
0.000000	0.042202	0.000000
0.000000	0.527004	0.000000
0.000000	-0.024268	0.000000

TABLE A-3-30 FLIGHT CONDITION 30

REFERENCE CONDITION

THEDA =	0.0 RADIANS
Q =	0.0 RAD/SEC
U =	169.00 FT/SEC
W =	-10.00 FT/SEC
PHI =	0.0 RADIANS
P =	0.0 RAD/SEC
V =	0.00 FT/SEC
R =	0.0 RAD/SEC

TRIM PARAMETERS

ELEVATOR =	10.98 DEGREES
REACTION NOZZLE DY =	10.98 DEGREES
THRUST DEFLECTION ANGLE (SIGMA) =	78.34 DEGREES
ENGINE RPM =	57.53 PERCENT OF MAXIMUM
AILERONS =	0.00 DEGREES
RUDDER =	0.00 DEGREES
SIDE VANE ANGLE (LAMBDA) =	0.00 DEGREES
REACTION NOZZLE DX =	0.00 DEGREES
REACTION NOZZLE DZ =	0.00 DEGREES

A MATRIX

0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	-2.055846	0.012840	-0.025128	0.000000	0.000000	0.000000	-0.292380
-32.035897	10.000000	-0.076415	0.135186	0.000000	0.000000	0.000000	0.000000
0.000000	169.000000	-0.321072	-0.028885	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.014197	0.000000	0.000000	0.000000	-0.451157	-0.042129	-0.015424
0.000000	0.000000	0.000000	0.000000	31.832873	-10.000000	-0.529348	-169.000000
0.000000	0.184564	0.000000	0.000000	0.000000	-0.015039	0.023888	-0.200514

B MATRIX

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.181219	0.034907	0.001093	0.216343	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.029151	0.494659	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.141229	0.221849	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.270293	0.003549	-0.007673	0.068243	0.001279
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.144207	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.003549	0.046142	-0.000868	0.002275	0.016623

WIND DISTURBANCE MATRIX

0.000000	0.000000	0.000000
-0.012840	0.000000	0.025141
0.076415	0.000000	-0.185231
0.321072	0.000000	0.028899
0.000000	0.000000	0.000000
0.000000	0.042147	0.000000
0.000000	0.529576	0.000000
0.000000	-0.023898	0.000000